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THROUGH THE EYES OF THE EDITOR

Glen E. Tilton discusses the factors involved in impression making for complete dentures and describes his technique for making impressions with a minimum of pressure. His definition of "minimum pressure" is a practical guide to the interpretation of his technique, and it is worthy of study. He points out that the impression should be extended to the limits of "patient tolerance." This limitation is one which has been overlooked by the designers of some current impression techniques. It is certainly a sound limitation because prosthodontic treatment involves more than providing dentures that have retention. The patient must be able to wear the dentures with such comfort that they seem to be a part of the patient himself. The author favors the open-mouth impression procedure as a means for determining the limitation of the extent of the dentures. The author states that the "anatomy of variant types of the mouth is essentially the same," and that the same impression procedure should be used for all mouths. This may be subject to question because, while the anatomy is "essentially the same," there are variations in the underlying bone which may indicate variations in technique in order to protect soft tissues from mechanical damage from rough bony surfaces underneath. The impression technique described is practical and meets the requirements he has set up for it. The method for providing relief over a torus palatinus is unusual and effective. It will overcome the complaint of some patients that "there is air" in the relief area of the palate. The technique for both impressions is fundamentally sound and allows for the control of the placement of pressures as well as properly formed denture borders.

J. Malcolm Booth describes a technique for using reversible hydrocolloids for complete denture impressions. The procedure involves the construction of an individual water-cooled tray for these impressions. If the tray is accurately formed, the impression material can be properly controlled in relation to the tissues with the possible exception of the borders. A rim of wax placed on the borders of the tray might overcome this objection. He also suggests the use of acrylic resin occluding surfaces on the teeth, with metal contacting surfaces at selected locations. While this would simplify the development of the occlusion after the bases are formed, it would also subject these teeth to abrasion from food to the extent that they would need to be rebuilt from time to time.

Dayton Dunbar Krajicek discusses the importance of esthetics in complete dentures and describes a technique for making anterior acrylic resin teeth which satisfy his demand for individually characteristic teeth for each patient. He emphasizes the importance of having the teeth look natural and harmonious when they are on "exhibition" as in a smile. He has checked the measurements of natural teeth of many patients against those of Black and of artificial teeth currently on the market. He found that teeth as they are supplied to the profession do not have sufficient variation. Rather than "break" sets of teeth which is a simple way to overcome the difficulty, he makes plastic teeth for his patients to their individual requirements. The technique is simple enough, and it does pro-

vide an opportunity for color modification that is difficult, if not impossible, with stock teeth. It should be pointed out that the availability of good-looking teeth is not enough. The proper and artistic arrangement of teeth is equally important.

C. H. Blanchard has suggested that selective grinding may be done to provide space for denture bases for some patients who cannot be subjected to surgical treatment. This is another example of common-sense treatment planning with the general welfare of the patient as the major consideration.

William L. McCracken discusses mouth preparations for partial dentures. Each phase of the procedure is related to the diagnosis or to the effect of making specific preparations. The sequence of the procedure is logical, and the techniques suggested are sound and described in detail. There can be little argument with the statement that "success or failure of a partial denture may well depend upon how well the preliminary steps were accomplished." Undoubtedly many partial dentures fail because of the failure to have the preliminary preparation of the mouth properly carried out. The discussion of an acceptable means for dentists and laboratory technicians to correlate their efforts is timely and should be a guide toward better partial denture service. The conservative treatment suggested for teeth requiring restorations has merit and should appeal to patients.

W. H. Wilson suggests that an examination of patients which does not include a thorough diagnosis of the occlusion is inadequate. He lists six objectives of an adequate examination and describes the procedures which are used to make this diagnosis. The hinge axis is located for each patient, and the occlusion is studied on study casts mounted on an adjustable articulator. With this information as a basis, the treatment is planned.

Emil D. Soltis discusses the three dimensions in the occlusal forms of posterior teeth and describes in detail the technique for forming the shape and size of the various cusps. The practical application of the technique is most obvious in complete mouth rehabilitation. However, there is an equally important value in the technique. If it is followed out with meticulous care, the student will really understand the interrelation of cusps of teeth as they contact and move over each other. While the technique might seem to be complicated, it is really quite simple because each cusp is considered in relation to its opponent in each of its functional ranges of movement. The concept on which the technique is based is that the relative positions of the upper and lower jaws are determined by the condyles posteriorly and by the cusps of the teeth anteriorly when the teeth are in contact. The objective is to have uniform and simultaneous contacts of teeth anteroposteriorly and laterally in all functional ranges. The statement which implies that this can not be accomplished with a curved occluding surface (made up of cuspless teeth) is open to question. If the curvature shown in Fig. 4 was worked out in harmony with the condyle paths, a uniform contact could be developed in protrusive positions. However, the objective can be achieved more easily by the use of cusps and by the procedures suggested.

Kenneth C. Pruden describes a technique for using reversible hydrocolloid impression materials for pinledge attachments for fixed partial dentures. The procedure seems to be relatively simple and accurate. It is obvious that the pinholes must be perfectly parallel if the casting is to fit the preparation. There is less margin for error in the preparation with this technique than if pre-formed pins are used.

Arthur Edward Kahn describes the use of reversible hydrocolloids in the construction of the unit-built porcelain bridge. The procedure is adapted from the technique for making individual porcelain jacket crowns as he described it in a previous article (J. PROS. DEN. 5:687-697, 1955). If the hydrocolloid impression materials are sufficiently accurate for other fixed restorations, it would seem that they could be used as well for porcelain restorations. Since the pontics are made as individual thimbles over a metal frame, the problem of shrinkage is no greater than for an all-metal restoration. The restoration would have the advantage of improved esthetics at the risk of a slightly greater tendency for breakage. This technique offers the possibility of relatively simple repair procedures when they are necessary.

Eugene W. Skinner and Noel E. Hoblit report on their quantitative studies of the accuracy of reversible and irreversible hydrocolloid impressions. Measurements were made on impressions of a special model and compared to measurements of the model itself. Both the reversible and irreversible impression materials were shown to provide the necessary accuracy for practical use. It is noteworthy that the bulk of impression material in the tray and the care used in handling the impression have a bearing on the accuracy of the impression. The importance of these two factors must not be overlooked in the practical use of the hydrocolloid materials.

Fred A. Hohlt and Ralph W. Phillips evaluate various methods employed for constructing working dies from hydrocolloid impressions. The test impression procedures were standardized so the variables would be limited to the die formation techniques. The tests involved an examination of the accuracy of contact areas resulting from the various techniques. The results indicate certain parts of these techniques which require special care to maintain accuracy. The errors detected were in a mesiodistal direction, and this suggests the possibility of errors in a buccolingual direction which were not examined.

E. W. Skinner and Cecil C. Gordon report on some experiments on the surface hardness of dental stones. The formation of a die which has a very hard surface in a hydrocolloid impression is a perplexing problem as well as a technical necessity. The tests of the surface hardness of these dies are almost as difficult to evaluate. The authors have made an evaluation of their tests which included consideration of a number of variables, and make some significant statements in the summary which are of practical significance.

Ralph W. Phillips and Fred J. Dettman report on their studies of some variables associated with copperplating of dental impressions for making more accurate dies. The most apparent difficulty is in metallizing the impression surface so it will receive the deposit of copper. They point out certain factors which affect the quality of the surface, and make comparisons of the effectiveness of various metallizing solutions. This work is a step in the direction of solving the problem of making accurate dies for fixed dental restorations.

Jean Nadeau suggests the use of magnets for stabilizing the complicated prosthesis which is necessary after radical surgical treatment of the palate and orbit. The restorations are ingenious for the patient whose treatment is described. The technique for using the magnet is not too difficult to be practical. It can be adapted to meet the requirements of other patients who need sectional prosthesis.

Louis J. Boucher, Leslie Wilde, and William Frackelton describe the treatment of a patient who had sustained major shrapnel wounds about the face. The prosthetic phases of treatment consisted of the construction of an ingenious internal nasal prosthesis for the support of the plastic surgical reconstruction. The evident cooperation between the dentists and the plastic surgeon was a major factor in the successful treatment of this patient.

—Carl O. Boucher

Editorial

PROSTHODONTIC TERMINOLOGY

Frequent reference has been made to the confused state of the terminology used in prosthodontics. The loose use of terms to express concepts and procedures has resulted in gross misunderstanding of the concepts and the procedures being discussed. The terminology which was adequate for a young profession has become inadequate as added knowledge has given new connotations to previously accepted terms. The new knowledge requires a more precise connotation of terms for an adequate distinction between concepts. Eventually, the "slang" of the profession must give way to an accurate and more or less universal "language" of the profession.

Slang is language which is comprised of currently used, but usually ephemeral terms, especially coined or clipped words, or words used in a special sense. The use of "professional" slang is apparent in conversations between dentists. For example, we often hear dentists speak of a *prophy,* an upper *bi,* establishing *vertical,* making a *partial,* taking *centric, capturing* centric relation, etc.

While "coined" words are the new words in the language and obviously new words must first appear as "coined" words, their use and introduction must be approached with caution. A "coined" word may be meaningful to its author, but it may be misleading or confusing to the reader. If a word is to be "coined," it must have logic and reason as its background. For it to be only euphonious or spectacular is not enough reason for its use.

The correct choice of words to express an idea is important to an author because the communication of his idea is his objective. The dentist and the student are the readers of the chosen words. The words must have the same meaning to them as they do to the author. The need for a precise system of nomenclature with precise definitions for terms used in prosthodontics is obvious.

This problem has been studied by a committee of the Academy of Denture Prosthetics for many years. Progress was slow until, during the past three years, the Academy as a whole began to work on it seriously. Approximately one thousand terms were compiled, and defined by the Fellowship of the Academy at its meeting in 1953. These terms and definitions were studied by each of the Fellows during the next year, and those terms or definitions about which there was not complete agreement were studied at the meeting of the Academy in 1954. The results of this study have been restudied by a committee of six, and are now nearly ready for publication and scrutiny by the profession. It is to be hoped that a *start* has been made toward a satisfactory, adequate, and modern terminology for prosthodontics.

That everyone will agree to the terminology used in the "Glossary of Prosthodontic Terms" is too much to hope for. Habits and personal preferences will cause some to reject some terms and some definitions. This is good because our professional "language" is not static. It must be subject to critical analysis at any time in order that it can develop along with the knowledge of the profession. Our terminology must be a living, changing, and constantly improving means for communication of ideas between the members of the dental profession.

When the new "Glossary of Prosthodontic Terms" makes its appearance in an early issue of the JOURNAL OF PROSTHETIC DENTISTRY, the comments of the profession regarding it will be welcome. The constructive suggestions will be given thorough consideration in future revisions of the Glossary.

CARL O. BOUCHER

A MINIMUM PRESSURE COMPLETE DENTURE IMPRESSION TECHNIQUE

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HOW MUCH PRESSURE is a minimum pressure? The minimum pressure is just the amount that will hold movable tissue far enough away so that the required coverage may be secured, and in substance, it is little more than the weight of a free-flowing material. An impression made with no pressure at all will not cover enough area to afford retention, stability, or esthetic value to a denture.

The pressure applied in impression making must be equally balanced throughout the entire area of the impression. The tissues of the mouth, or indeed any tissue of the body, will not tolerate constant pressure without change; therefore, pressure on tissue in function beneath a denture must be momentary.

In the opinion of the writer, all denture-bearing tissue will be at rest when the mandible is in the rest position.

MOUTH EXAMINATION

The approximate area to be covered by the denture foundation will be readily determined by visual and digital examination. Look for maxillary tuberosities that jut out and those that project downward enough to interfere with the lower denture. They must be removed. The maxillary torus requires special treatment, and this will be considered as the technique is developed, but very rarely is its removal necessary. Rather than trying to fit a denture over a sharp ridge, or jagged spicules of bone, these remnants of the alveolar process should be removed. Bulbous or hyperplastic tissue always overlies jagged bone.

STRESS-BEARING TISSUES

All tissues are stress bearing in some degree, except the jagged processes. Fixed mucofibrous tissue supports the major part of the load, with the movable tissue playing a minor role in a varying amount which depends upon its location. There are many mandibles on which there is no fixed fibrous tissue capable of carrying a load. For that reason, the movable tissue must be regarded as the entire supporting area.

Read before the Academy of Denture Prosthetics in New York, May 4, 1955.
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AREA COVERED

A denture should not be extended to the limits of the oral cavity, nor to the limits of tissue tolerance, but rather to the limits of patient tolerance. A denture may be worn without tissue abrasion or injury, yet it may be uncomfortable and one to which the patient cannot adapt himself. This is attributable to unnecessarily overextended flanges, either in length, width, or in both.

ESTHETICS

Esthetic considerations begin in the impression. The upper mucobuccal space should be approximately half filled. The upper mucolabial flange should be thin, and short enough not to have the effect of shortening the lip. Where complete resorption of the ridges has taken place, palpation is a valuable aid, and more to be depended upon than visual observation.

The lower buccal vestibule should not be filled to its fullest extent, even with a very fluid material. The buccal flange at the buccal frenum need not be made thin, but it must be made short in order to free the strong tissue attachment. The width of the denture flange over the frenum can very well be determined by palpation. The external surface of the face must be smooth to the touch. The lower labial flange must be made to preserve the facial profile, and the length and curve of the lip. All denture borders should be thick enough to be rounded.

POSITION OF THE MANDIBLE

The wide-open mouth is the most logical position for making the impression. The movable tissues wrap themselves around the denture border with increasing tension as the jaws open to their extreme functional position. The normal functions of the jaws and adjacent musculature are many in addition to mastication. The denture borders are in no way influenced by the muscles of mastication, except at the distobuccal angle of the lower denture. The muscles in this region are not actually in contact with the denture, but as they contract, they force yielding tissue forward and inward against the denture border. A wide-open mouth makes provision for this muscle action.

IMPRESSION MADE IN TWO SECTIONS

The impression of the mucofibrous tissue (fixed tissue), which comprises the major stress-bearing area, should be entirely completed before beginning the impression of the mucobuccal and mucolabial tissue (yielding tissue). Each section should be made of a material that will produce the desired result with one insertion, thus eliminating the possibility of error.

ALL MOUTHS ARE TREATED ALIKE

The anatomy of variant types of mouths is essentially the same, and since the basic principle of impression making cannot be changed, there can be no need for the use of different techniques and materials in dissimilar types of mouths.

TESTING FOR STABILITY AND RETENTION

There is no known way of testing for the stability and retention of an impression, except the knowledge of the way the impression was made. If the impression was made with only the weight of a free-flowing material, then, and only then, can the dentist be sure that the stability and retention obtained in the impression will serve indefinitely and without tissue change.

WHO IS THE MAKER?

The dentist is simply the architect who drafts the plans, and the patient makes his own impressions. When this principle becomes fully realized, the problem changes from a complicated one to one that is simple and easy.

Fig. 1.

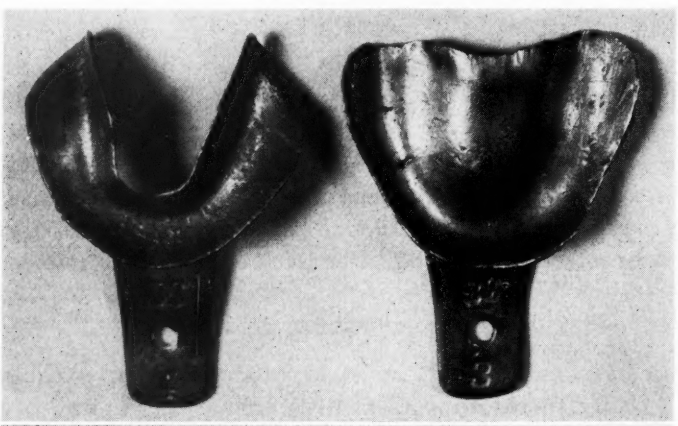

Fig. 2.

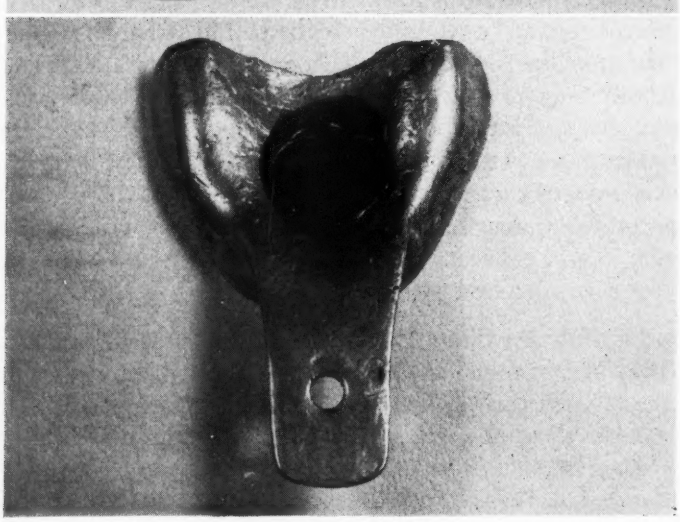

Fig. 1.—S.S. White Britannia metal trays.
Fig. 2.—The imprint of the dentist's finger in modeling plastic on the upper tray.

S.S. White Britannia metal trays are used (Fig. 1). This metal is pliable enough to be shaped to suit individual cases. Four sizes of these trays are sufficient to suit all patients.

The imprint of the dentist's finger is placed on the upper tray to limit the amount of pressure that can be applied, and to center the pressure over the supporting area (Fig. 2).

Attention is directed in Fig. 3 to two critical areas: (1) The malar process of the maxillary bone over which the tissues are very thin and easily abraded. The tray must be relieved at this point, and the relief continued distally over the tuberosity to admit an unhampered flow of a free-flowing material. The shrinkage of the plastic base material will manifest itself first at this point and continue distally over the tuberosity. (2) The tray must be freely relieved over the pterygomaxillary notch, especially when a heavy frenum is present over the notch.

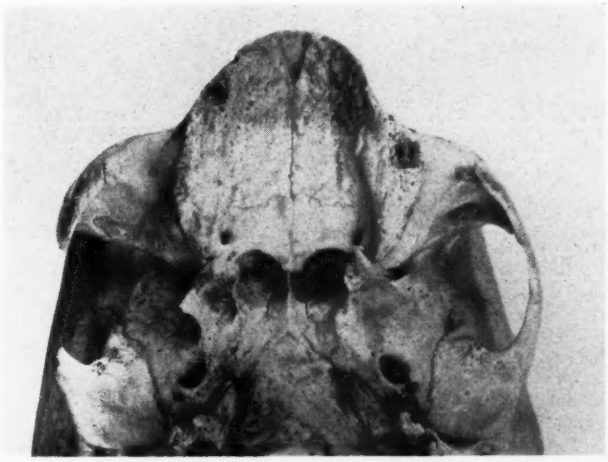

Fig. 3.—The bony foundation for the upper denture.

THE MAXILLARY IMPRESSION

The first and very important question that arises, is how much movable tissue can be covered by the denture (Fig. 4). It has been taught, and correctly so, that enough of the yielding tissue must be covered to effect a valve seal, but not enough to interfere with muscle function or glandular action. The literature is replete with instructions of this character. In my opinion, no technique has been described that conveys clearly just how this can be accurately accomplished. A technique for this procedure should be so definite, and easily understood, that two or more dentists might make an impression for the same patient, with exactly the same results.

The initial modeling plastic impression is made in a suitable tray (Fig. 5).

The tray is prepared for the second insertion (Fig. 6). Known excess is removed. The border is reduced to the beginning of the roll. This provides for an escape-way when the plastic is heated. The flange should be at least 4 mm. thick. A deep groove is cut in the region of the median line which permits the plastic, when heated, to move in all directions away from the ridge. The impression surface is heated by the use of a torch to a depth of 2 mm. The heating

Fig. 4.

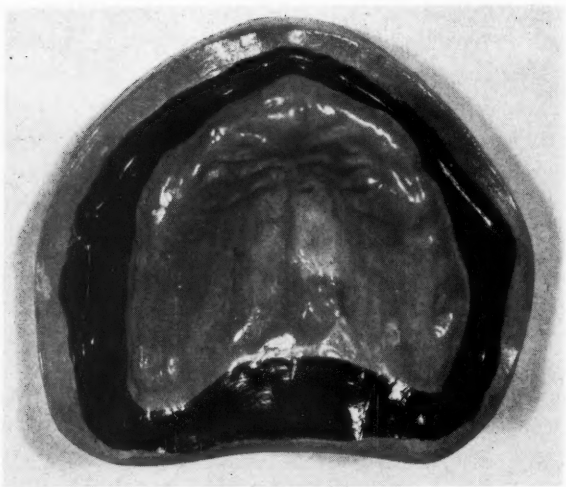

Fig. 5.

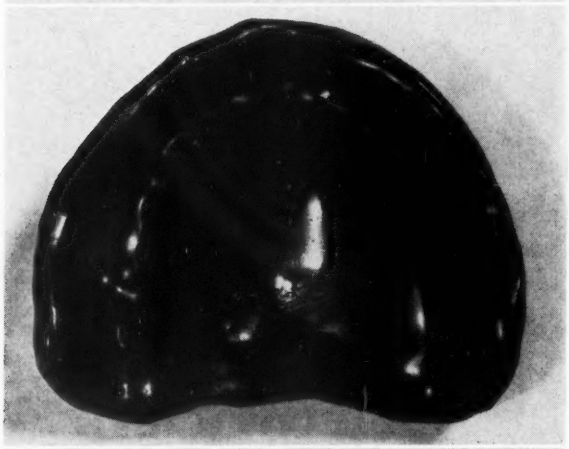

Fig. 6.

Fig. 4.—A cast of the maxillary arch made from a modeling plastic preliminary impression showing the location of fixed and movable tissues.

Fig. 5.—The initial impression.

Fig. 6.—The tray prepared for the second insertion.

should be done slowly, so that sufficient penetration can be made without causing the material to flow. The impression is inserted, and by the use of one finger it is gently forced into position at a right angle to the basal seat, chilled, and removed. The metal tray is removed, and the modeling plastic impression tray is reinforced if it is found to be weak at any point. An imprint of the dentist's finger is placed in the center of the supporting area of the modeling plastic tray as a minimum balanced tissue tension is continually the principle objective.

The deep recess made in the plastic (Fig. 6) should not be completely closed (Fig. 7). The known excess is removed, and the tray is marked with an indelible pencil around the border, through the notch, and across the prospective distal termination. The mucous membrane is dried and the impression base inserted. The pencil marks will transfer to the mucous membrane. More material may be removed, and this step repeated until the desired results are obtained.

The labial and buccal frenula must be completely relieved. Other yielding tissue may be covered slightly, as it will be checked subsequently for overextension. The flexure line is not necessarily the distal termination of the denture, and it may be encroached upon slightly.

The tray or impression base should be checked again for weak spots, after it has been completely outlined (Fig. 8). The distal portion should be reduced in thickness to about 5 mm. This will permit the patient to close his mouth partly while the dentist raises the buccal tissues and introduces a strong stream of water to facilitate the removal of the final impression.

The base is made ready for the reception of a zinc oxide and eugenol impression paste (Fig. 9). The borders are trimmed to a thin edge to prevent the paste from piling up. This serves to check any overextension, as there should be approximately 1 mm. of paste covering the entire border. A very liberal relief must be made over the unyielding tissue at the median line and the posterior palatal seal. Relief is made over the tuberosities and forward along the margin over the malar process. This amount of preparation of the base will suffice for a great many patients. Where there is a torus or extremely hard tissue at the median line, or when a metal base is to be made, the impression base or tray preparation is more complex.

Large escape holes are made through the tray in the relief at the median line (Fig. 10).

The escape holes are covered with wax to prevent the impresssion paste from escaping (Fig. 11).

The base tray is filled with a zinc oxide and eugenol paste and inserted, and gently placed in position by the pressure of one finger under the center of the tray while the patient holds his mouth wide open and his lip down (Fig. 12).

The impression paste covering the relief area is uncovered (Fig. 13). The relief area is filled with very soft plaster, inserted in the mouth, and held under extreme pressure until the plaster has set. The excess plaster is eliminated through the holes in the tray. This provides an automatic relief (Fig. 14).

For many years, I have felt that a relief of this kind gave perfect patient satisfaction. An arbitrary relief is seldom right, as it provided either too little

Fig. 7.

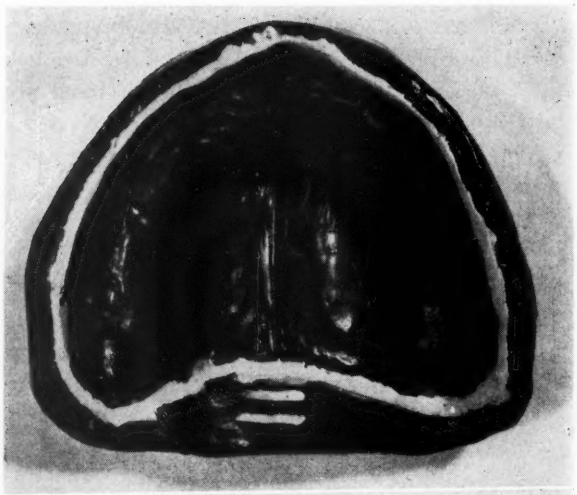

Fig. 8.

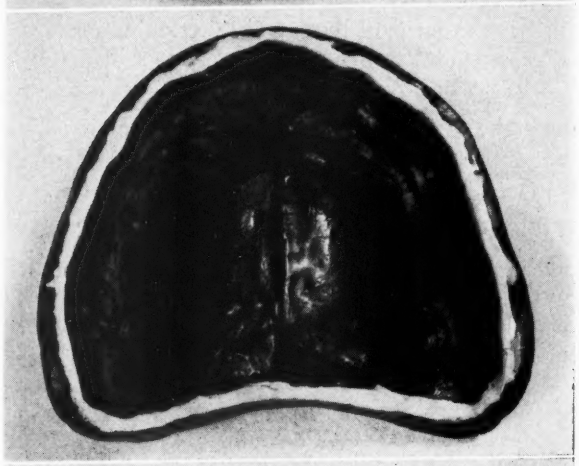

Fig. 9.

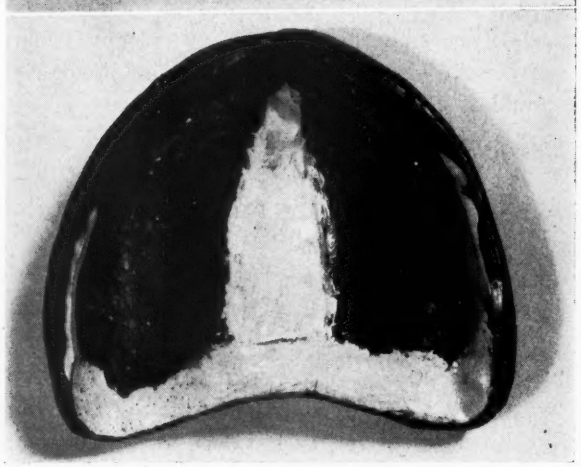

Fig. 7.—The recess in the modeling plastic tray should not be completely closed. (Compare with Fig. 6.)

Fig. 8.—The outlined impression base.

Fig. 9.—The impression base is prepared for a zinc oxide and eugenol impression paste wash.

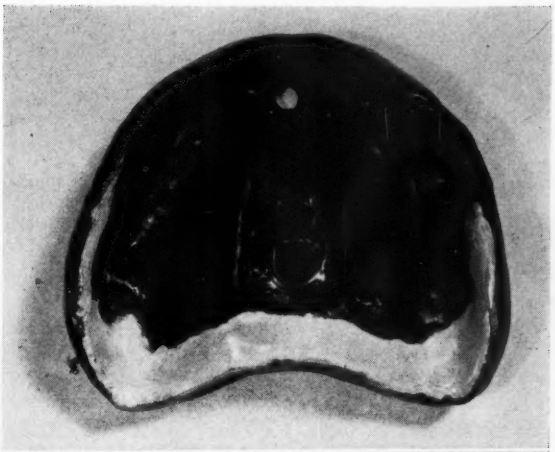

Fig. 10.

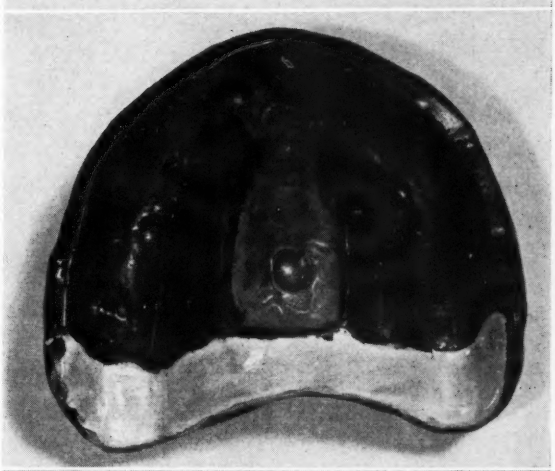

Fig. 11.

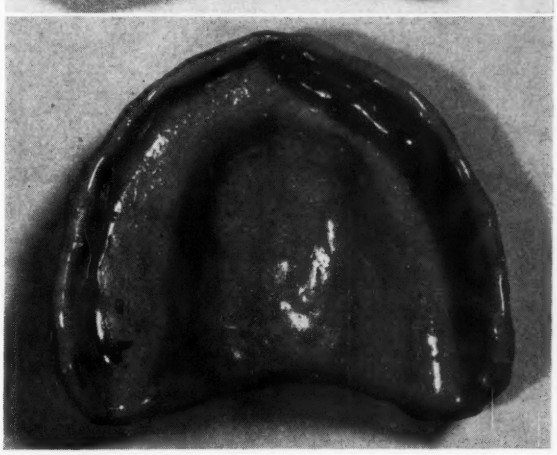

Fig. 12.

Fig. 10.—Escape holes are provided at the median line.
Fig. 11.—Wax over the escape holes.
Fig. 12.—The zinc oxide and eugenol impression.

Fig. 13.

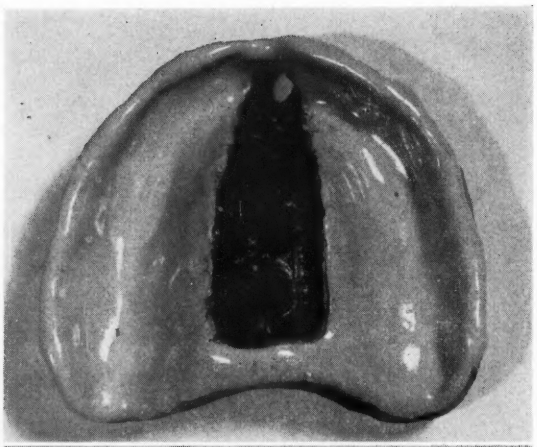

Fig. 14.

Fig. 15.

Fig. 13.—The impression material covering the relief area is removed.
Fig. 14.—Very soft plaster is substituted in the area of relief.
Fig. 15.—The completed impression with accurately determined relief and borders molded in wax.

or too much relief. If too little relief was provided, further relief of the finished denture was necessary. If too much relief was provided, globules of air beneath the denture was the result, and this resulted in patient annoyance.

Several methods of providing automatic relief have been tried.

1. Soft wax gave varying results.
2. Soft plaster works very well.
3. The edge of the recess was covered with dry foil, and a zinc oxide and eugenol paste was used instead of plaster. This works even better than plaster.
4. Where a metal denture was to be used, or where a troublesome torus existed, the base was reinforced with wire. The entire relief area was removed and the first impression was placed in the mouth, held in place with heavy pressure while soft plaster was brushed on the mucous membrane through the large hole in the tray. This gave a perfect result.
5. An injection technique. This is a perfect and easy method.

A syringe is attached to the base tray over the incisive papilla. The syringe connects with a hole leading to the relief space. One escape hole is provided at the most distal part of the relief space in the tray. The syringe is filled with impression paste, the base is inserted, and the impression material is injected into the relief space while the base tray containing the first impression is held under heavy pressure. The excess material injected passes out through the hole at the distal end of the relief.

Several types of syringes have been used.

1. A penicillin disposable syringe may be adapted for this purpose. The 1,000,000 unit size makes the best syringe I have found to date.
2. An anesthetic capsule may be used, but it does not hold enough material unless the relief space has been made quite shallow.
3. A Bosworth glass tube that cement liquid is packaged in makes an ideal syringe.
4. Any glass tube may be used. A plunger may be made by wrapping cotton around an orangewood stick, and lubricating it with mineral oil.

MOLDING THE WAX BORDER

An impression wax that is moldable at mouth temperature is warmed and brushed on the entire border of the impression in excess, including the posterior palatal seal. The wax is cooled, and the impression is inserted and left in the mouth until the temperature of the wax has reached the temperature of the mouth. This will require about eight minutes, but the time may vary according to the temperature of the wax when it is inserted.

After sufficient time has elapsed, the impression is held firmly in place, and the patient is instructed to open his mouth wide, force the upper lip down as far as possible, and protrude the mandible. Since wax flows sluggishly, it must be given ample time in which to flow.

The impression is chilled and removed. The vestibule will be completely filled with wax. The thickness of the flange in the buccal vestibule should be reduced to one-half its width, and that in the labial vestibule made quite thin. With

the reduction in thickness, the border can be extended a little higher. A small amount of additional wax is brushed on the entire border and the posterior palatal seal. The impression is placed in position in the mouth for the same length of time and movements as before. This completes the impression (Fig. 15).

Forcing the lip downward may be called an arbitrary movement, but actually it is not. The lip must have freedom of movement, and this is the only movement that will mold the anterior denture border to the proper height. Actually, there is no space in the labial vestibule when natural teeth are in position. The soft tissues of the lips should be supported, and not pressed from their normal position. Therefore, the length of the denture flange should be just as suggested, and only

Fig. 16.

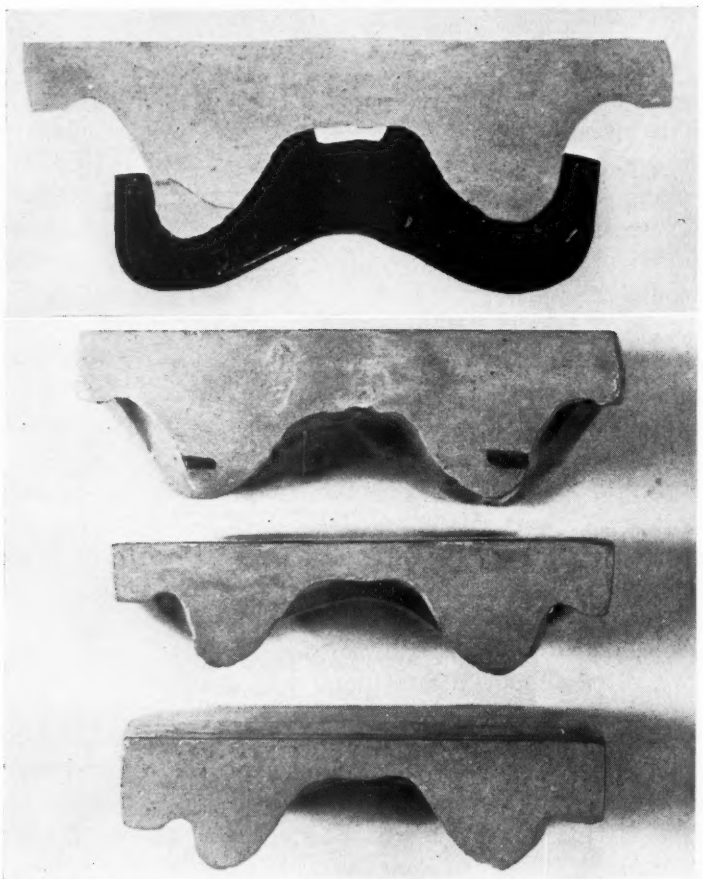

Fig. 17.

Fig. 16.—A cross section of a cast of an average mouth, showing approximately where movable tissue begins and where the impression base or tray must be terminated.

Fig. 17.—Cross section of three casts from the same mouth. *Above:* The cast made from the preliminary impression. *Middle:* The cast over which the denture was made. *Below:* The cast made in the same base as the middle one, but a free-flowing material was used to mold the border instead of wax. It can be easily determined which produced the greatest length of flange, showing that the length of flange that may be formed depends entirely upon the plasticity of the impression material.

heavy enough to insure proper strength and a rounded border. The protrusion of the mandible will mold the distobuccal angle of the impression border, and occasionally it will be too thin for flange support, and a little more wax must be added.

In my opinion, wax is the only material that can be depended on to give a uniform result every time and complete the entire border operation with, at the most, only two insertions (Figs. 16 and 17).

MANDIBULAR IMPRESSIONS

In many mouths, there is little or no fixed tissue on the mandible that will carry any load. Therefore, the movable tissue becomes the stress-bearing area (Fig. 18).

A preliminary impression is made in modeling plastic (Fig. 19). The distolingual portion of the tray is cut at an angle to prevent the material from being forced too far distally.

The known excess of modeling plastic is removed from the preliminary impression. The distal end of the lingual flange is arbitrarily fashioned to fill the fossa to the extent that was determined by examination of the mouth (Fig. 20).

The preliminary impression is made more accurate by heating its surface slowly and uniformly to a depth of at least 2 mm. with a small blowtorch, and seating it gently in the mouth. The impression is chilled and removed (Fig. 21).

A cast is made in this impression. A shellac tray which is at least 3 mm. thick is made over this cast (Fig. 22). The tray is made rigid by reinforcing it with low-fusing metal (Fig. 23). This serves well in mouths that are considered normal, but in mouths where an automatic relief is desired, the tray should be reinforced by the addition of more of the same shellac material. This enables the dentist to remove the required amount of material easily for the automatic relief. The relief is made by the injection method as described for the maxillary impression. In my opinion, this should never be attempted except for elderly patients who cannot or will not have surgery.

The retromolar pad may be well covered if covering it does not interfere with the upper denture. Usually, covering one-half or two-thirds of the pad will suffice, as there is no reason to crowd the tissue in this region. Crowding the tissue will only add to patient discomfort, even though it may not cause tissue irritation.

The distobuccal angle of the tray is rounded just short of soft tissue movement. The portion of the tray that lies in the buccal vestibule is cut back to the external oblique line of the mandible. This line is not the termination of the impression, but only the starting point. The tray is cut short in order to free the buccal frenum. The thickness of the tray at this point is determined by palpating the cheek, which should feel smooth. The labial flange is formed to give free movement to the lip and a normal outward appearance of the face.

Fig. 18.

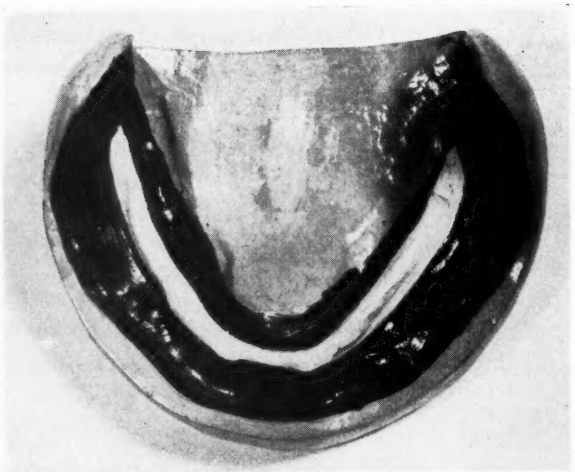

Fig. 19.

Fig. 20.

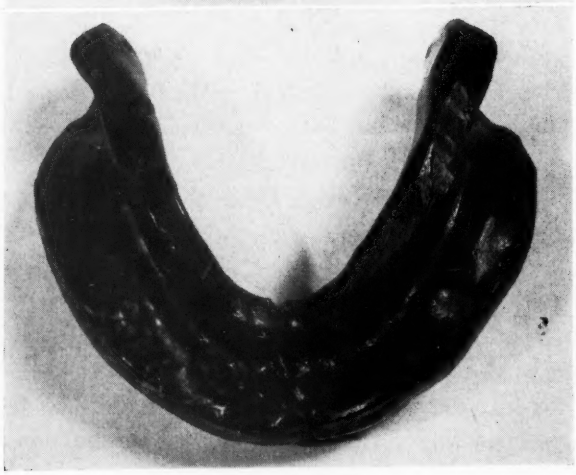

Fig. 18.—A cast made from a preliminary impression. The light area indicates the fixed tissue, and the dark area indicates the movable tissue.

Fig. 19.—A preliminary modeling plastic impression.

Fig. 20.—The known excess of modeling plastic is removed, and the distal end of the lingual flange is formed arbitrarily.

Fig. 21.

Fig. 22.

Fig. 23.

Fig. 21.—The completed modeling plastic impression.
Fig. 22.—The shellac tray.
Fig. 23.—The completed reinforced tray in position on the preliminary cast.

MEASURING THE LENGTH OF THE LINGUAL FLANGE

The tongue must have freedom of movement. This is the most critical step in forming the tray. When the tongue is protruded, it should be permitted two-thirds of the protrusion of which it is capable.

The tray at its most distal border will act as a stop to complete protrusion of the tongue. The tray will be left thicker in the anterior than in the posterior region. The development of the exact width of the flange will be explained when the finishing of the impression is described.

The trimming is continued until the patient will say that he cannot feel his tongue against the tray. This is a very good indication that the tray has been trimmed uniformly, and to the correct length. Of course, this step is an arbitrary one, to some extent, but it works out in practice.

Fig. 24.

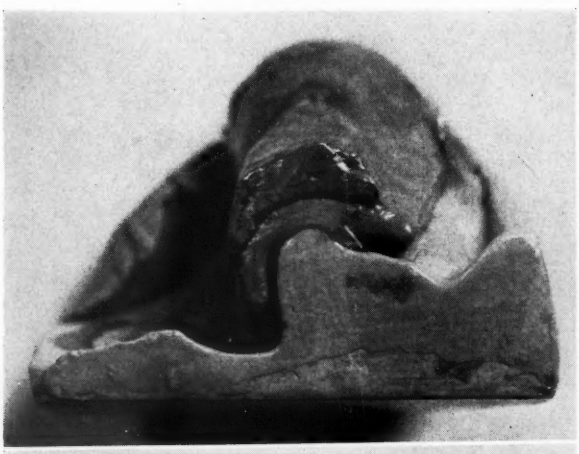

Fig. 25.

Fig. 24.—A cross section of a cast and shellac tray showing the location of relief. The crest of the ridge is not relieved and serves as a stop.

Fig. 25.—The shellac tray properly prepared. The light portion is not relieved.

After the borders of the shellac tray have been formed in length and breadth, the tray is freely relieved in all areas (including the parts covering the retromolar pads), except a very narrow area over the crest of the ridge. This unrelieved portion will act as a stop (Figs. 24 and 25).

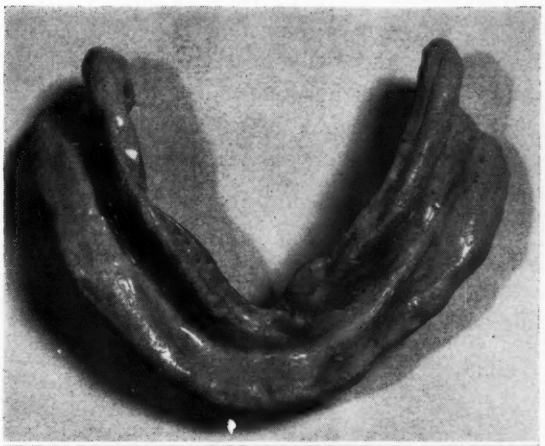

Fig. 26.

Fig. 27.

Fig. 28.

Fig. 26.—The first zinc oxide and eugenol wash impression.
Fig. 27.—The completed impression.
Fig. 28.—Impression prepared for a simple automatic relief. More complicated cases may be handled by the injection method as described for the maxillary impression.

The tray is filled with a free-flowing zinc oxide and eugenol paste, and gently settled to place in the mouth. *It is held gently in place* while the mouth is wide open. As soon as the impression material begins to stiffen, the patient is instructed to move just the *tip* of his tongue back and forth across his lower lip. This allows the material to move into the alveololingual space and over the floor of the mouth anteriorly. The action also elevates the lip slightly, which molds the labial border of the impression. Any other movement of the tongue would trim these margins too short.

The impression is removed (Fig. 26), and any spots of the tray that show through in the buccal or labial portion are cut back, and the distolingual border is thinned to the dimensions of the finished denture.

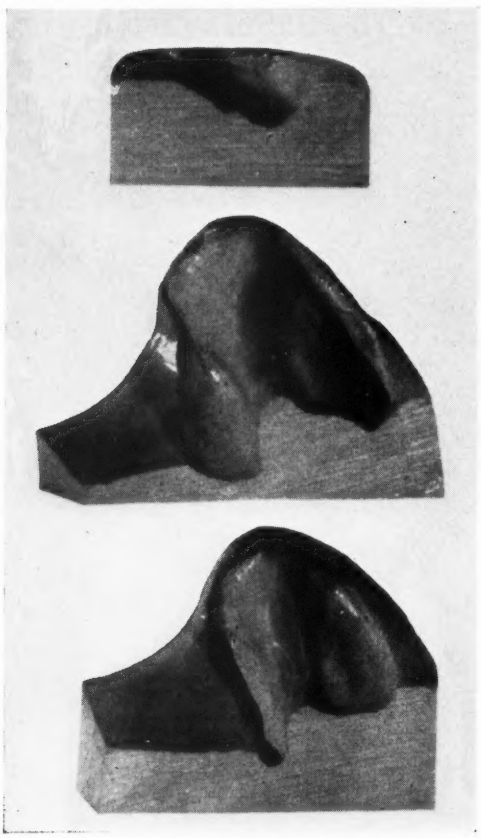

Fig. 29.—Cross sections of casts of the same mouth. *Above:* The impression was made without pressure or direction. *Middle:* The preliminary cast. *Below:* The final master cast.

The lingual flange in the anterior region of the floor of the mouth is not measured as fixed distance. It is made not thicker than one-half the distance between the movable tissue attachment and the orifices of the ducts of the sublingual salivary glands. This distance is very narrow in many mouths.

The part of the impression over the crest of the ridge is relieved, and the lingual flange is relieved slightly throughout its entire area except at the distal end. This provides for a free flow of the impression material.

When the first impression is trimmed and relieved, it is filled with a free-flowing zinc oxide and eugenol impression material, preferably of a contrasting color. It is seated in the mouth and held as before. The patient is directed to hold the mouth open wide, and to move the tip of the tongue across the lower lip, and to elevate it slightly. This will mold the lower border of the impression. Then the patient is directed to protrude the tongue to the fullest extent. This produces a rounded margin on the entire lingual border of the impression (Figs. 28, 29, and 30). Should the anterior lingual flange be finished too narrow, wax is added to make it thicker. It is never made longer.

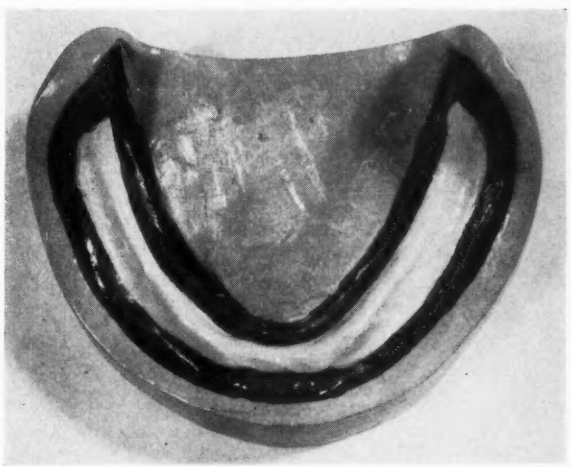

Fig. 30.—The final master cast. Compare this with the preliminary cast, Fig. 18.

SUMMARY

A technique for making impressions for complete dentures with a minimum pressure has been described. The procedure is applicable to any type of ridge form. An injection method for providing relief for hard areas in the mouth is described. This procedure allows these tissues to supply their full share of support without injury. The impression borders are developed so they will not be objectionable to the patient.

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REVERSIBLE HYDROCOLLOID AND PLASTICS IN COMPLETE DENTURE CONSTRUCTION

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THREE OF THE MOST COMMON problems that confront the prosthodontist in making complete dentures are: (1) the control of an excessive flow of saliva during impression making, (2) preventing distortion of the soft tissues of the mouth, due to an inaccurate tray or undue pressure of impression materials, (3) the development of centric occlusion which is in harmony with centric relation. The technique to be described was designed to overcome these causes of failure without increasing chair time, and to eliminate some of the too frequent postoperative treatments.

THE IMPRESSIONS

Preliminary impressions are made in the usual manner in modeling plastic at the first appointment. At this time the patient is instructed to take two 50 mg. Banthine tablets by mouth one hour before the following appointment. This amount of Banthine will reduce salivation greatly during the making of the master impression.

Stone casts are made from the preliminary impressions. One thickness of baseplate wax is molded over the casts to act as a spacer and a means for holding plastic tubing in place. One-eighth inch plastic tubing (which may be obtained from most hobby shops) is fastened around the borders and in the palatal portion of the upper wax spacer, with the ends of the tubing extending anteriorly (Fig. 1). A similar wax spacer is formed over the lower cast, and plastic tubing is attached around its borders in a similar manner. The tubing is held in place on the wax by pieces of paper clips (Fig. 1). The sides of the clips are attached to the baseplate wax with sticky wax.

A sheet of acrylic resin tray material is prepared in a mold made by embedding one baseplate gutta-percha blank to its thickness in stone, and removing it after the stone is set (Fig. 2). The stone mold is lubricated with lanolin. A thick syrupy mix of tray resin is placed in the mold and rolled out with a lanolin-coated bottle.

The sheet of tray resin is molded over the baseplate wax and the plastic tubing. The edges of the sheet of tray resin are trimmed with scissors just short of the borders on the cast. After setting, the trays are trimmed more accurately with a

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coarse wheel on the lathe. The entire procedure may be handled by the assistant or laboratory technician, and should not take over one-half hour for each tray.

The trays are removed from the casts, and the baseplate wax is removed. A bead of utility wax is placed across the postpalatal seal area of each tray to control the hydrocolloid. Three utility wax stops are placed inside each tray to prevent

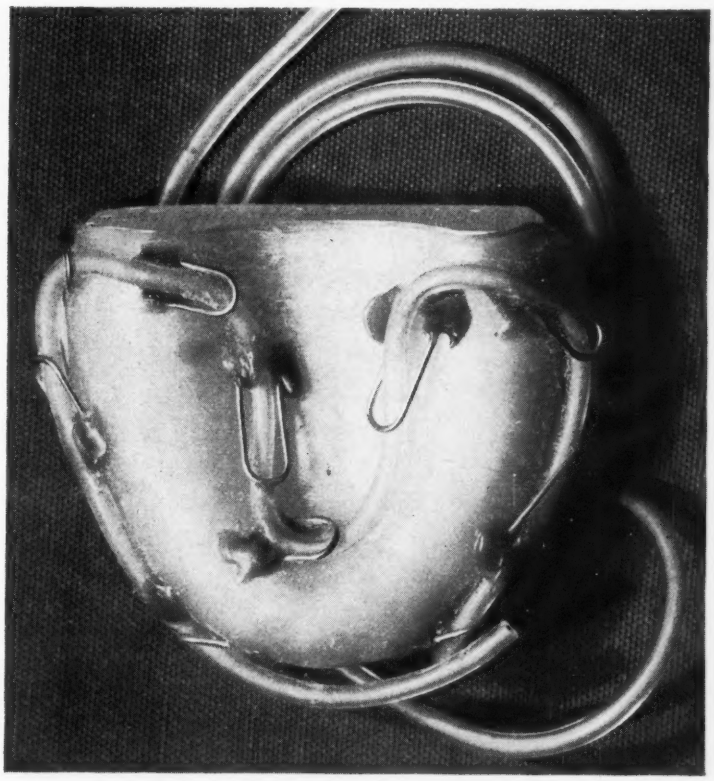

Fig. 1.—The wax spacer and plastic tubing in place on the preliminary cast. The tubing is held in place by paper clips and sticky wax.

the tray from being pushed through the impression material while the impression is made (Fig. 3). This wax causes no appreciable tissue displacement as the wax is softened adequately by the warm hydrocolloid. A piece of larger rubber tubing is connected to the small plastic tubing by means of metal tubing in order to provide circulating water for cooling the hydrocolloid. When rubber tubes are attached to the ends of the plastic tubing, the tray is ready for use.

THE FINAL IMPRESSIONS

The hydrocolloid impression material is prepared in the tubes in the usual manner, and the tempered material is placed in the tray. The patient's mouth is wiped dry with gauze sponges. A small amount of hydrocolloid is placed, with a large hydrocolloid syringe or the fingers, in regions where air might be trapped. The filled tray is inserted into the mouth and seated as guided by the utility wax

Fig. 2.—The stone block used for forming the tray plastic into sheets for adaptation over the spacer and plastic tubing.

stops. The loose end of one rubber tube is placed in a jar of cold tap water. (Ice may be placed in the water jar if the tap water temperature is above 70° F.) The loose end of the other tube is attached to the saliva ejector. The tray is held in place with a slight but steady pressure for seven minutes. A timer should always be used. About a quart of water will be drawn through the tubing by the saliva ejector in this amount of time.

The impressions are removed and poured immediately or stored in a humidor. (A good humidor can be made by placing moist disposable tissue in a glass refrigerator dish, the lid of which has been coated with petroleum jelly.) The impressions should be poured as soon as possible, and covered with damp disposable tissue while the stone is setting. The casts may be removed from the impressions after one hour.

Fig. 3.—A completed maxillary acrylic resin water-cooled tray. Utility wax is placed for the postpalatal seal and for stops. Note the connections for the rubber tubing.

JAW RELATION RECORDS

The vertical dimension is established and tracings to locate centric relation are made at the third appointment. By means of these records, the casts are mounted on an articulator. Porcelain posterior teeth are set on the upper wax occlusion rim, and acrylic posterior teeth are set on the lower occlusion rim.

The wax dentures are tried in the mouth at the fourth appointment, and any necessary adjustments are made. Amalgam or gold inlay restorations are placed on the occlusal surfaces of the lower second bicuspids and first molars, and the dentures are processed.

PERFECTION OF THE OCCLUSION

At the fifth appointment, the dentures are placed in the mouth. A small amount of the correct shade of quick-curing resin is mixed to a sticky consistency, and a thin strip of it is placed on the occlusal surfaces of the lower posterior acrylic teeth. The mouth is dried, the dentures are seated, and the patient is instructed to close lightly into centric occlusion. The dentures are removed as soon as it can be done without distorting the resin, to prevent moisture contamination of the resin. Discrepancies in the occluding surfaces are filled in with more acrylic resin by the brush technique, and the resin surfaces are carefully carved and polished. Thus, an accurate occlusion is obtained which would be extremely difficult to obtain by grinding. The metal restorations in the acrylic resin teeth overcome the problem of loss of vertical dimension due to the softness of the resin. The patient is instructed to return every six months so the occlusion can be readjusted with additional quick-curing acrylic resin, if necessary.

SUMMARY AND CONCLUSIONS

A technique for complete dentures which makes full use of the favorable properties of reversible hydrocolloids and plastics has been described. The custom made water-cooled tray is an essential part of the impression procedure. The plastic tubing used in these trays is adequate for the purpose even though it is not as good a conductor of heat as metal. The trays are inexpensive and the tubing can be reused.

The advantages of the impression technique are: (1) Excess salivation is controlled by the use of Banthine. (2) The fine accuracy and flow of reversible hydrolloid are used effectively and with control by an accurately fitted individual tray. (3) Washes in other materials are unnecessary.

The use of metal stops at selected locations on acrylic resin posterior teeth make it possible to develop an accurate occlusion without danger of an eventual loss of vertical dimension. The addition of acrylic resin to the occluding surfaces of the other lower posterior teeth makes the adjustment of the occlusion simple after the dentures have been processed. This readjustment may be repeated at six month intervals, if necessary. The readjustment of occlusion in this manner will overcome the disadvantage of abrasion of acrylic resin teeth.

The technique is easily adaptable for use in making immediate and partial dentures.

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PERSONALIZED ACRYLIC RESIN ANTERIOR TEETH

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ONE OF THE MOST important aspects of prosthetic dentistry, and yet one of the most consistently neglected is that of esthetics—the ability to *harmonize* what we create with its environment. In denture construction, esthetics considered from is broad aspect obviously embraces much more than the teeth themselves; however, our concern in this article must be limited to the primal aspect—the teeth.

Roberts,[1] defining esthetics pertaining only to the teeth, said, "Artificial dentitions which duplicate natural teeth reflect not only the ravages of time but also the periodic care by a good ethical dentist."

In order to attain a rewarding goal such as this, Sears[2] points out that we must provide pleasing, natural-appearing teeth which in some measure will tend to remove the patient's inhibitions, give him poise, and generally improve his outlook on life. We recognize that if the face were always in repose, our objectives would be simplified. Rather, it is when the teeth are on *exhibition,* when the patient is speaking, smiling, and laughing, that esthetics undergoes the most rugged tests. Success hinges upon how well the prosthodontist has concealed the art.

But esthetics is not new to the dental profession. Wilson[3] devoted an entire chapter to this subject. With the overwhelming stockpile of favorable evidence which has been constantly before the profession, it remains difficult to understand why we have ignored the full impact and importance of this need. True, artificial dentures do more nearly satisfy patients' demands for appearance today, in contrast to the era before acrylic resins, but there is still much to be accomplished before the ultimate of success is within our grasp. No derogatory reflections upon tooth manufacturers' efforts are intended—rather they are to be greatly commended for the excellence of their products. This does not imply, however, that we can continue to sanction the basic shortcomings of stock teeth.

Careful scrutiny, coupled with sincere unbiased observation and evaluation of the natural dentition, will convince those who are interested that stock teeth, whether they are porcelain or acrylic resin, are not the carved reproductions of natural teeth. In contrast, artificial substitutes *must,* of necessity, *be* the actual reproductions of nature to completely satisfy their esthetic requirements as to shape and size.

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The shading, hue, and personalization of each tooth varies with the influences of acquired or natural physical habits, age, and time. Experience, developed from our interest in the color variance of natural dentitions, dictates that we should select lateral incisors with more gray, and cuspids possessing more yellow than we find in sets furnished by the manufacturers.

If all this is true, why have we not insisted that we be furnished teeth of this nature? The answer reflects our own blindness to our needs. Sears[4] indicated that one manufacturer actually tried to market such teeth. Almost all of them were returned by the dentists, sarcastically indicating that the factory did not even know how to match shades. At the present time, at least one tooth manufacturing company is characterizing individual denture teeth. An attempt to supply the needed personalized anterior teeth for each individual patient, however, would result in bewildering confusion. So it is that the artisans are doing their job as well as they are able in the earnest desire to furnish the profession with stock teeth. We turned the job over to them many years ago. The artisan is now supplying the artist with his art.

As members of the dental profession, our education, training, and experience in practice has developed in each of us to varying degrees an individual esthetic sense about anterior teeth. Primarily, our business is teeth—we see them every day. And yet our greatest fault is that we have not been seeing them at all. Rather, we focus our attention upon carious lesions and calcareous deposits, and entirely overlook the teeth as they exist and blend into each patient's facial characteristics. In order that we might imitate nature, we must see the natural dentition in regard to mold, shade, variation in size and placement. We must awaken and redevelop this individual esthetic sense in order to satisfy the artistic obligation to each patient and the profession. Obviously, we cannot approach the same plan of creative genius as the Creator, but if we continue to list esthetics as one of the primary requisites of complete dentures, where are the results of our artistic progress?

A logical beginning is first the mold of artificial anterior teeth, and next their respective analogy to each other. Williams,[5] as the result of research and investigation, presented to the profession his widely accepted classification of faces, and their grouping into typal forms for the selection of anterior teeth. For the sake of simplicity of classification and convenience of use, it was established that a square tooth form was to be employed with a square face, tapering form for the tapering face, and ovoid form for those with an ovoid face. This theory was predicated on the basis that "like forms are in harmony." Some dentists still believe in this legend, according to Sears,[6] as firmly as they ever believed in Santa Claus or the Easter Bunny, although both Stein[7] and Wright[8] have disposed of the typal theory quite effectively. Nature will *not* conform to any rules of standardization. Rather, the logical criterion for tooth selection must be one which incorporates individual observations of natural tooth forms. Who can substantiate a basis for criticism in this method, when teeth so selected for the edentulous patient will follow the plan found in nature in belonging and blending into the facial outlines?

SIZES OF TEETH

Next is our consideration concerning the size of the artificial teeth in relation to each other. The foundation for our calculations will be G. V. Black's table of measurements from his *Descriptive Anatomy of the Human Teeth.**

TABLE I. BLACK'S MEASUREMENTS

	BREADTH OF THE CROWNS OF UPPER ANTERIOR TEETH IN MILLIMETERS		
	GREATEST	AVERAGE	LEAST
Central incisor	10	9	8
Lateral incisor	7	6.4	5
Cuspid	9	7.6	7

My inquisitive nature regarding anterior teeth promoted the procedure of recording the mesiodistal width of all natural upper anterior teeth during the process of conducting complete oral examinations for veteran patients admitted to the Veterans Administration Center, Wadsworth, Kansas. A review of these records, for the eighteen-month period in which they were conducted, reveals figures which coincide favorably with Black's measurements as listed in Table I. Limitation of space permits only three of these cases to be cited. They are selected for their representation of the group as a whole.

TABLE II. NATURAL DENTITION

	BREADTH OF CROWNS OF NATURAL UPPER ANTERIOR TEETH IN MILLIMETERS		
	CENTRAL INCISORS	LATERAL INCISORS	CUSPIDS
1. 31-year-old white man, 6′ tall, 200 pounds (square face, tapering mold)	9	6	7.5
2. 42-year-old white woman, 5′1¼″ tall, 107 pounds	8	6	7
3. 56-year-old white man, 5′11½″ tall, 165 pounds (tapering face, ovoid mold)	8	5.5	7

The most significant fact resulting from these measurement studies appears to be the lack of central incisors whose mesiodistal width was less than 8 mm. *Not one* was encountered. Yet the study was conducted on both men and women, tall individuals as well as short, demure and rugged, lean and stocky—with a sincere attempt to exclude none, and to faithfully and honestly record the existing data. The conclusion must then be, that, although admittedly these teeth do exist

*S.S. White Dental Manufacturing Co., ed. 5, 1902.

in nature, their existence is in the minority. They represent the exception rather than the rule.

A comparative study of stock teeth representing more than one manufacturer indicates their essential shortcomings. The existing basic failure is that of too much uniformity in the comparative width of the upper anterior teeth. Table III catalogues some of the average molds of stock teeth.

TABLE III. ARTIFICIAL DENTITION

	BREADTH OF CROWNS OF ARTIFICIAL UPPER ANTERIOR TEETH IN MILLIMETERS		
	CENTRAL INCISORS	LATERAL INCISORS	CUSPIDS
1. M 45/C plastic	8.3	6.6	7.6
2. M 42/C plastic	7.6	6.0	7.0
3. M 263 porcelain	7.5	5.8	7.0
4. M 335 porcelain	8.4	6.4	7.6

Criticism of accepted procedures is *not* the intent of this paper. Rather, its scope challenges decadent practices in prosthetic dentistry which cannot continue to endure. The solution to the primary obstacle, that of tooth mold, can most logically be solved by providing our patients with actual reproductions of the natural dentition. This is accomplished in a practical manner by constructing *permanent* metal flasks of extracted maxillary central incisors, lateral incisors, and cuspids. By saving all extracted teeth for possible use in this project, the accumulation of permanent metal flasks increases rather rapidly, and soon represents the wide variance of anterior molds necessary to encompass the entire scale of tooth individuality. The technique of flask construction was suggested by Hardy.[9]

PERMANENT FLASK CONSTRUCTION

1. The desired set of natural central incisors, lateral incisors, or cuspids is mounted in a plaster block in such a way that the entire portion of both crowns, and approximately 2 mm. of each root extend beyond the surface of the block. By means of a permanent rubber-base impression material, such as Kerr's Permlastic, placed in a previously prepared auto-cured resin tray, an accurate impression of the two natural teeth can be easily secured. Tap water serves as a lubricant before securing the impression.

2. A heavy mix of Akratex die material vibrated into the previously constructed permanent rubber-base impression provides the accurate working duplications of the two natural teeth. After twenty minutes setting time, the stone teeth are removed from the impression. More teeth can thus be quickly obtained, if needed, throughout the procedure. It must be noted here that two sets of either

central incisors, lateral incisors, or cuspids are used together in the fabrication of *one* permanent metal flask.

3. A one-inch section of truck radiator hose, two and one-half inches in diameter (procurable from any service station) is the next item to be utilized. It will remain usable almost indefinitely. The greatest labiolingual circumference of each stone tooth is determined by visual examination and scribed on the tooth with a pencil. The stone teeth are next lubricated with petroleum jelly or lubricating oil. The section of radiator hose, compressed by means of inlay tongs so that it assumes an oblong shape, is completely filled with a heavy mix of Gray Investment.* The previously lubricated four stone teeth are placed lingual surface down into this investment, just to the pencil line scribed on each tooth.

4. After the Gray Investment has completely set, the rubber ring is removed. By means of a sharp knife, a V-indexing cut is placed on each end of the surface of the investment. A third index is cut into the top surface of the investment in the form of a diagonal groove which bisects the investment proper, and thus separates the two sets of anterior teeth. The Gray Investment is knife trimmed around all stone teeth until the pencil line is exposed. Then all the stone teeth can be easily removed (Fig. 1).

Fig. 1.—Four teeth properly mounted in a block of Gray Investment.

5. Following one hour of bench drying, the stone Akratex teeth and the investment mold (without the teeth inserted into it) can be placed into a cold inlay furnace. The temperature is carried slowly to 500° F. and maintained for at least one hour. The Akratex teeth will tolerate this heat without disintegrating. Both teeth and mold will now be moisture free. *This is most imperative.*

6. The dry teeth are placed into the original indentations on the surface of the investment. The section of truck radiator hose is placed in position around the dry mold, but this time in such a manner that at least one-half inch extends above the surface of the investment. Since we are now prepared to pour the top half of the permanent metal mold, the hose serves to confine the molten metal until cool. *No separating medium is needed at this time.*

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*Ransom & Randolph Co., Toledo, Ohio.

The ultimate success of this entire procedure can be attributed to the metal used which is known as Cerrotru metal.* An evaluation of its composition reveals that it contains only two elements in the following proportions: 58 per cent bismuth, 42 per cent tin. The melting temperature, 281° F., is of exceptional importance for it is within the range permitting melting over an open flame, and yet when solidified will not be affected by the temperature of boiling water. One ingot contains sufficient metal for the construction of three normal size flasks.

7. Approximately one-fourth of the Cerrotru metal ingot is melted into a metal ladle over the open flame. When completely molten, it is removed from the flame, but *not* poured into the rubber ring until some four minutes later. This metal remains in the liquid state for an exceedingly long period of time and *if* poured *before* the metal begins to crystallize around the edges of the ladle, the residual moisture will be driven from the stone teeth and investment, resulting in damaging bubbles on the approximating surface of the metal. No special case is required in the pouring of the molten metal into the rubber ring other than the important consideration of *not pouring the metal while it is too hot.*

8. After the metal has been allowed to bench cool and has solidified, the rubber ring may be removed. The completed top half of the metal flask will, at this time, permit removal from the investment mold without posing any difficulties. If both teeth and investment were thoroughly dry and the Cerrotru metal allowed to cool in the ladle, at least four minutes before attempting the pour, the tooth approximating surface of the flask will faithfully record each of the three indexing lines as well as the accurate duplication of the labial half of each of the four teeth.

9. The four moisture-free stone teeth are now placed, labial surface down, into the newly poured half of the metal flask. The final step involves pouring molten Cerrotru metal against metal. This makes a separating medium necessary. Graphite in the form of a soft lead pencil is used for this purpose. The entire surface of the flask is marked with the pencil, excluding the teeth, thus insuring a complete separating film of the graphite on the surface. The section of radiator hose is placed around the metal flask. A portion of Cerrotru metal is heated as previously described, allowed to cool approximately four minutes, and then poured from the ladle onto the top half of the metal flask. After the metal has completely bench cooled and solidified, the rubber ring is removed. The two halves of the metal flasks are separated easily, the Akratex teeth are removed, and all traces of graphite are eliminated from the tooth contact surfaces of the flasks by scrubbing them with carbon tetracholride.

The end product is the permanent metal flask into which we can process acrylic anterior teeth of the previously selected base shade, incorporate the desired incisal and gingival colors, personalize the labial surfaces, and provide these advantages in teeth which are accurate duplications of natural teeth. Their practical value to any practice is that of constant availability, thereby eliminating the tedious preliminary laboratory procedures before processing anterior teeth.

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*Obtainable from Metal Goods Corporation, North Kansas City, Missouri, in the two pound ingot form.

PACKING AND PERSONALIZING ANTERIOR TEETH

A polymer whose base shades conform to the numerical system of the shade guide of choice is desirable. The fundamental kit of concentrated stains needed should include small bottles of gray, white, yellow, and brown. A cross-linked monomer is utilized routinely in the fabrication of anterior teeth, for, with its use, an end product with a dense, hard, solvent resistant surface is atttainable. Also, it can be predicted that these teeth will retain their color permanently.

PACKING TECHNIQUE

1. The needed amount of polymer of the previously selected base shade for the central incisors, lateral incisors, and cuspids is placed in three small mixing jars. If the chosen base shade *should fail* to conform to what is desired, a small amount of stain may be added—for example, gray to the lateral incisor powder, or the yellow stain to the cuspid base (dentine) powder. In the event this is done, the mixture must be thoroughly agitated by vigorous shaking in a closed container so there is an even distribution of stain granules dispersed throughout. Each base powder is moistened with the cross-linked liquid, mixed for about one minute, and allowed to stand in the closed mixing jar until the mass develops the correct consistency for packing.

In this interim, the preselected metal flasks are placed on the laboratory bench in readiness. The consistency of the acrylic resin in each of the three jars must be slightly beyond the sticky stage before attempting to trial pack. When this stage has been noted, a small globule of the acrylic resin from the central incisor jar is placed in each of the two indentations on the lingual surface of *that* flask. A similar procedure is carried out for the two lateral incisors and the cuspids. Enough acrylic resin to create a definite excess is used. Moistened cellophane is stretched over this surface of all flasks, each top half is seated, and the three flasks are placed in a small flask compress and tightened slowly. The loaded compress is placed under running hot tap water for one minute. Since the flasks are metal, heat is conducted to the acrylic resin immediately.

2. The flasks are removed from the compress, and separated so the excess acrylic can be eliminated. It is usually desirable to trial pack for the second time in the same manner without adding more acrylic resin. This insures the density of the teeth.

3. Upon completion of the second trial pack, a small portion of the incisal tip of each tooth is cut away by means of a No. 10 detachable surgical blade mounted in a handle. By this time the resin mass is at a doughy consistency. The indicated incisal (enamel) blend, in the form of dry powder, is added to all teeth corresponding to the area of incisal base tip which was removed. This dry incisal powder is added slightly in excess, and then it is moistened with monomer. Cellophane is placed over the teeth, the top half of each flask is put in position. The three flasks are placed in the compress, and the loaded compress is placed under running hot tap water for a period of one minute.

4. Following flask separation and removal of excess material, a small section of the labiogingival portion of each tooth is cut away with the No. 10 blade. A gingival shade is chosen from the base powders. This is usually one slightly darker in hue than that selected for the bulk of the tooth. The gingival section is refashioned by sprinkling dry powder from a dispensing bottle into the area which has just been removed. An excess of powder is added and then it is moistened with the liquid. Areas in the incisal portion which may be insufficiently filled are noted at this time, and must be corrected before flask closure. Trial packing is done in the same manner as before. It must be emphasized that moistened cellophane is *always* used between flask halves, not only for each trial pack, but also for the final processing of the teeth.

5. The three separated flasks must, at this stage, reveal the six anterior teeth with a hard, dense appearance and of the desired shade, hue, and blend. Having been subjected to four one-minute trial packing episodes, the acrylic resin is now rubbery in its consistency.

STAINING

1. To produce a fine stained check line on the labial surface of a tooth, a slice is made in the desired location with a No. 10 blade. For this cut, the blade is held at a 45 degree angle to the tooth surface. This produces a flap of resin approximately 1 mm. in depth which, when elevated, will allow dry brown stain to be placed beneath it. The flap is then returned to its original position, the excess stain wiped from the surface, and the entire tooth is moistened with the liquid.

2. Unstained check lines or cracks are simulated by a cut on the labial surface with the knife blade held at a 45 degree angle. The flap is elevated, and white stain in the form of dry powder is placed under the flap. The remainder of the procedure is the same as that described earlier.

3. Simulated silicate fillings are placed in the mesial and distal aspects of anterior teeth by cutting the desired outline form into the rubbery resin with a No. 10 blade. The blade must be held at a 45 degree angle to the tooth surface to produce a flap. Dry brown stain is placed under the flap along its entire border, and the flap is allowed to return to its original position. The excess stain is wiped from the labial surface, and the tooth is moistened with the cross-linked liquid. When the monomer is applied, the illusion of a silicate filling becomes evident.

4. Decalcified areas (found primarily on the incisal third of lateral incisors) are produced by cutting away a portion of the uncured resin with small cuticle scissors at the desired location. Into this void, white stain in the form of dry powder is placed so that it *almost* fills the defect. The white stain is covered with the originally selected incisal blend powder. This completely obliterates the void. Of more importance, however, the incisal powder tones down the developmental defect so that it appears normal for the tooth.

The more common character staining features may be incorporated into the anterior teeth in a matter of seconds. By following the suggested methods, they become a definite part of each tooth and represent more than merely a superficial film.

After the desired staining has been accomplished, all flasks are covered with moistened cellophane and assembled for final closure and processing.

Only one-half hour of time has been utilized to pack the six anterior teeth, to incorporate both an incisal and gingival color, to personalize the labial surfaces, and to create the lifelike quality of the natural teeth.

The three flasks (locked in the compress) are submerged in room temperature water. The temperature of the water is raised gradually to 212° F. and allowed to boil for thirty minutes. The entire processing time consumes approximately forty-five minutes—none of which can be considered lost chair time. After curing, the flasks are immersed in cold tap water and separated. All teeth will remain in the lingual portion of the flask. Permanent metal flasks eliminate previously experienced complicated deflasking procedures completely. The teeth are easily removed from the flask, and have only a minor flash which can be eliminated with a laboratory knife. When this is removed, they are ready for use.

SUMMARY

A method of constructing permanent metal flasks which embody the contours of natural teeth has been described. The practical utilization of these flasks to process teeth of the desired shade and individuality was described. The personalized acrylic resin anterior teeth produced in this manner are an attempt to provide for the edentulous patient an esthetic, harmonious denture.

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SELECTIVE GRINDING VERSUS SURGERY

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THERE ARE PATIENTS who are unable or unwilling to submit to surgery for the development of space for a prosthetic appliance between the upper and lower ridges. The problem can be solved for some of these patients by selective grinding.

This is exemplified in a patient who was a diabetic and apprehensive of the recommended surgery (Fig. 1). He insisted upon having a partial denture. Since the pulps of his teeth were well receded, the height of the clinical crowns of the lower molars was reduced by grinding. This procedure accomplished the following results:

1. Space was created so that the upper partial denture could be extended to cover the maxillary tuberosity (Fig. 2). The lower second molar occluded with a metal base covering the tuberosity.

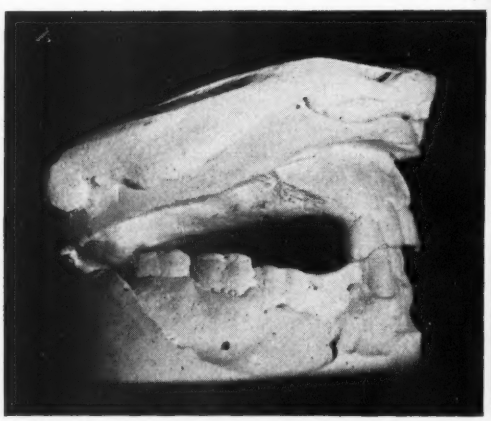

Fig. 1.

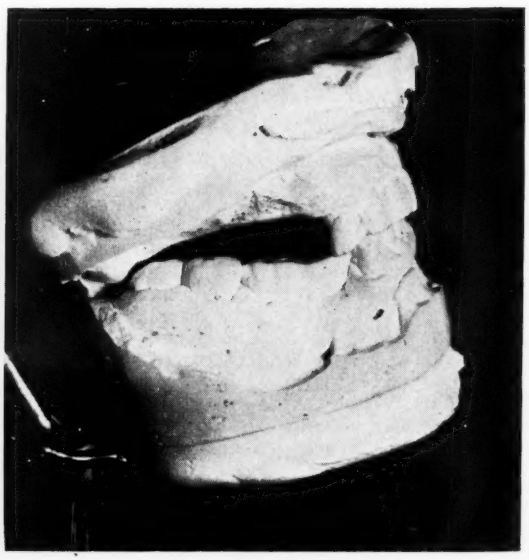

Fig. 2.

Fig. 1.—The relation of the upper and lower casts before the selective grinding.
Fig. 2.—The relation of the upper and lower casts after the molar teeth had been shortened by grinding. Note the space that has been developed between the lower molars and the upper ridge.

2. The occluding surface was made more nearly level, thus eliminating the most severe dislodging forces against the upper denture.

3. The amount of space for teeth between the ridges was increased.

4. The normal vertical dimension of occlusion and the normal anterior tooth contacts were maintained.

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†Deceased.

MOUTH PREPARATIONS FOR PARTIAL DENTURES

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MOUTH PREPARATIONS FOR partial dentures follow in logical sequence after oral diagnosis and treatment planning. We might say that mouth preparation begins where treatment planning leaves off.

Sound treatment planning is as essential to partial denture service as an architect's drawing is to the construction of a building. We are, in effect, planning the building of a structure, complete with foundation supports, which will last the longest possible length of time, one which will render the greatest possible service to the patient, and one which will best serve to fulfill that paramount requirement of partial denture service which is that of the preservation of the remaining oral tissues.

Regardless of the heights which dentistry may aspire to reach, the mechanical aspects of restorative dentistry will always be at least as important as the diagnosis which precedes the replacement of lost dental tissues.

In treatment planning for partial denture service, we must give considerable thought to the partial denture design which will best replace missing teeth, and which will restore dental functions with the least possible stresses being transmitted to the abutment teeth and to the residual ridges. Partial denture service should begin with the establishment of a condition of oral health so far as this is possible. This is best accomplished by utilizing all of the diagnostic aids available to us.

Before mouth preparation is initiated, there should be a critical evaluation of each remaining tooth, so that its relative importance to the rehabilitation of the mouth may be determined, and its retention or extraction justified. The diagnostic aids which we may and should use, in addition to visual examination of the mouth, are the roentgenogram, the vitalometer, and the critical examination of accurate study casts.

A study cast is more than an aid to diagnosis. Not only does it permit a critical evaluation of each remaining tooth when used in parallel with roentgenograms of those teeth, but upon the study cast will ultimately be evolved the blueprint of the proposed partial denture design.

Armed with neatly trimmed study casts and a view box, the dentist is better equipped to present to the patient a picture of his existing dental and oral condition, the need for and importance of correction, and the effect of his present oral condition on his future dental health status. This may be done at the chair:

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*Associate Professor.

however, the patient will, perhaps, be much more receptive if comfortably seated in the consultation room.

The occluded study casts will show to the patient the degree of vertical closure, to some degree the amount of vertical opening indicated, the effect of tooth migration on occlusal efficiency, and the importance of preventing further tooth migration and occlusal disharmony.

A lingual view of the occluded study casts will often disclose to the patient the effect of the loss of teeth and subsequent oral disorganization much better than a buccal view or a view of the single arch.

During this period of evaluation and treatment planning, the patient should be educated and conditioned to receive partial denture service, and should be trained to cooperate most fully in the care of the mouth and in the maintenance of the appliance which he is to receive. He should be advised fully of the limitations of a partial denture, and the importance of home care of the teeth and appliance.

Following a thorough examination of the patient, complete with roentgenograms, vitality test, and study casts, an initial treatment plan is evolved. This is primarily for the purpose of placing the remaining teeth in a condition of health and of obtaining the interest and the cooperation of the patient for the actual restoration of the missing teeth which will follow.

SURVEYING ACCURATE STUDY CASTS

Once the teeth not involved in the partial denture have been evaluated, and either removed as undesirable, or restored, the partial denture design may be decided upon. Utilizing the study casts, a path of insertion which will best avoid interference and which will provide uniform retention on all abutment teeth is determined by the use of a surveyor. At this time, teeth which at first it was thought could be restored and retained may be found to be malposed in relation to the other teeth and to create a serious point of interference to the insertion and removal of the partial denture. Such teeth often found malposed are lingually inclined lower bicuspids and maxillary bicuspids or molars which have migrated bucally.

Following a survey of the study casts, it may be found desirable to remove such malposed teeth as constituting uncorrectable areas of interference. Also, areas of bony prominence may be found which will interfere with the insertion of the partial denture, and rather than jeopardize suitable retention and maximum efficiency of the partial denture, such areas should be removed by surgery. Therefore, it is imperative that, during the initial period of diagnosis and treatment planning, the door be left open to a re-evaluation which may lead to a decision to remove undesirable teeth and areas of bony interference. For this reason, there must not be a commitment on the part of the dentist to the patient, nor a definite fee quoted, which cannot be changed after an actual survey of the study casts.

Why should the cast surveyor be used at all in the planning and construction of a partial denture? For the same reason a surveyor uses a transit to determine elevations, the cast surveyor gives us information which cannot be estimated.

If a partial denture is constructed without the aid of a surveyor, it may not be possible to insert or remove the finished appliance at all, due to existing interference. Even if the partial denture can be inserted, the insertion and removal may be so difficult as to cause injury to areas of soft tissue and bony eminences, injury to periodontal tissues, and excessive strain upon clasps and other parts of the denture.

If areas of retention have not been previously determined by the use of the surveyor, the location of retentive clasps may be incorrect so as to result in inadequate or excessive retention.

In any of these situations, time-consuming and embarrassing adjustments must be made on the finished appliance, not to mention a little "adjusting" here and there on the natural teeth. If this does not weaken the partial denture, it may very well "weaken" the patient's faith in his dentist. Remember, the laboratory technician is never blamed by the patient for an ill-fitting dental prosthesis.

In evaluating the factors which determine the choice of path of insertion and removal of the appliance, certain goals should be kept in mind. The finished prosthesis should be one that can be inserted and removed without difficulty; it should be retained against *reasonable* dislodging forces, and it must have the best possible appearance.

A survey of the study casts is best done in the office, and must be done with a cast surveyor, such as the Ney or the Jelenko surveyors. As a substitute for the survey of study casts by the dentist, they may be submitted to the laboratory technician, who will then determine the best possible path of insertion and removal and indicate areas of interference and insufficient or excessive retention on the abutment teeth. Close cooperation between the dentist and his technician is essential to satisfactory partial denture service and there must be an understanding between them which permits accurate transferral of information from one to the other.

It is important that the position of the cast in relation to the vertical arm of the surveyor, for a given path of insertion, be recorded on the base of the cast with vertical scratch lines, so that the path of insertion in relation to abutment teeth is before the dentist at the time mouth preparations are made (Fig. 1). This is necessary in order that a definite path of insertion may be maintained throughout the entire sequence of partial denture construction, from mouth preparation through the block-out of the master cast.

Let us assume that accurate study casts upon which a tentative partial denture outline or design has been drawn in pencil are ready to be sent to the laboratory for surveying. The technician will place this study cast on the movable base of the surveyor and proceed to determine the most suitable path of insertion which may be used.

Fig. 2 shows a chart which may be utilized to advantage at this time by both dentist and technician. The dentist may draw the proposed partial denture design on the diagram provided, using colored pencils as suggested. Mouth preparations yet to be accomplished are noted in the spaces provided so that the technician may be aware of them when making his survey. Further mouth changes, the need for which is established during this survey, are listed by the technician in

the spaces provided and returned to the dentist along with the study cast. The liaison between dentist and technician should be such that, if there are interfering teeth or areas of bony prominence which will interfere with a satisfactory partial denture as designed, the technician will so advise the dentist so that such areas of interference may be removed by extraction or surgery.

In such case, a second study cast is then necessary. This is again sent to the technician who will again survey to determine a path of insertion. Having arrived at a path of insertion which will permit a satisfactory design, the two sides and the dorsal of the base of the cast should be scored so as to record both the anterior-posterior and the lateral tilt of the cast in relation to the surveyor, which will represent the path of insertion which has been decided upon.

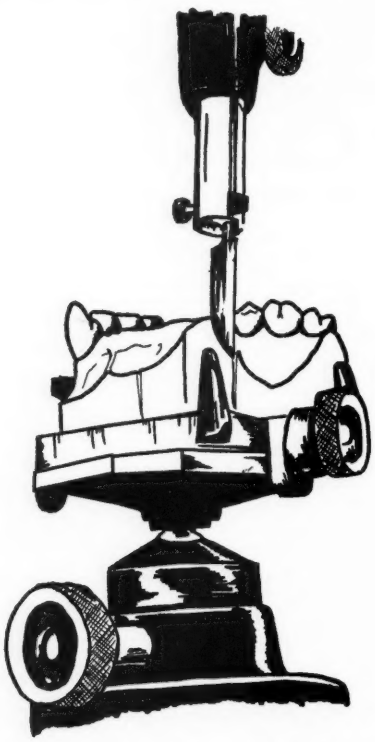

Fig. 1.—Study cast mounted on the movable base of a surveyor. Note the shape of the surveyor blade, slightly oversize in this illustration. Vertical scratch lines are scribed on the side and dorsal surface of the cast for future reference.

Other areas of interference which can be eliminated by disking and reducing tooth contours should be indicated on the study cast with a red pencil. At the same time, the technician should indicate on the chart the amount of disking to be done and whether slight or severe. If severe, it is then up to the dentist to decide whether or not a crown restoration will be necessary. The technician should also indicate areas where the retention is inadequate so that tooth contours may be changed by judicious grinding of enamel surfaces or the placement of restorations to increase tooth contours.

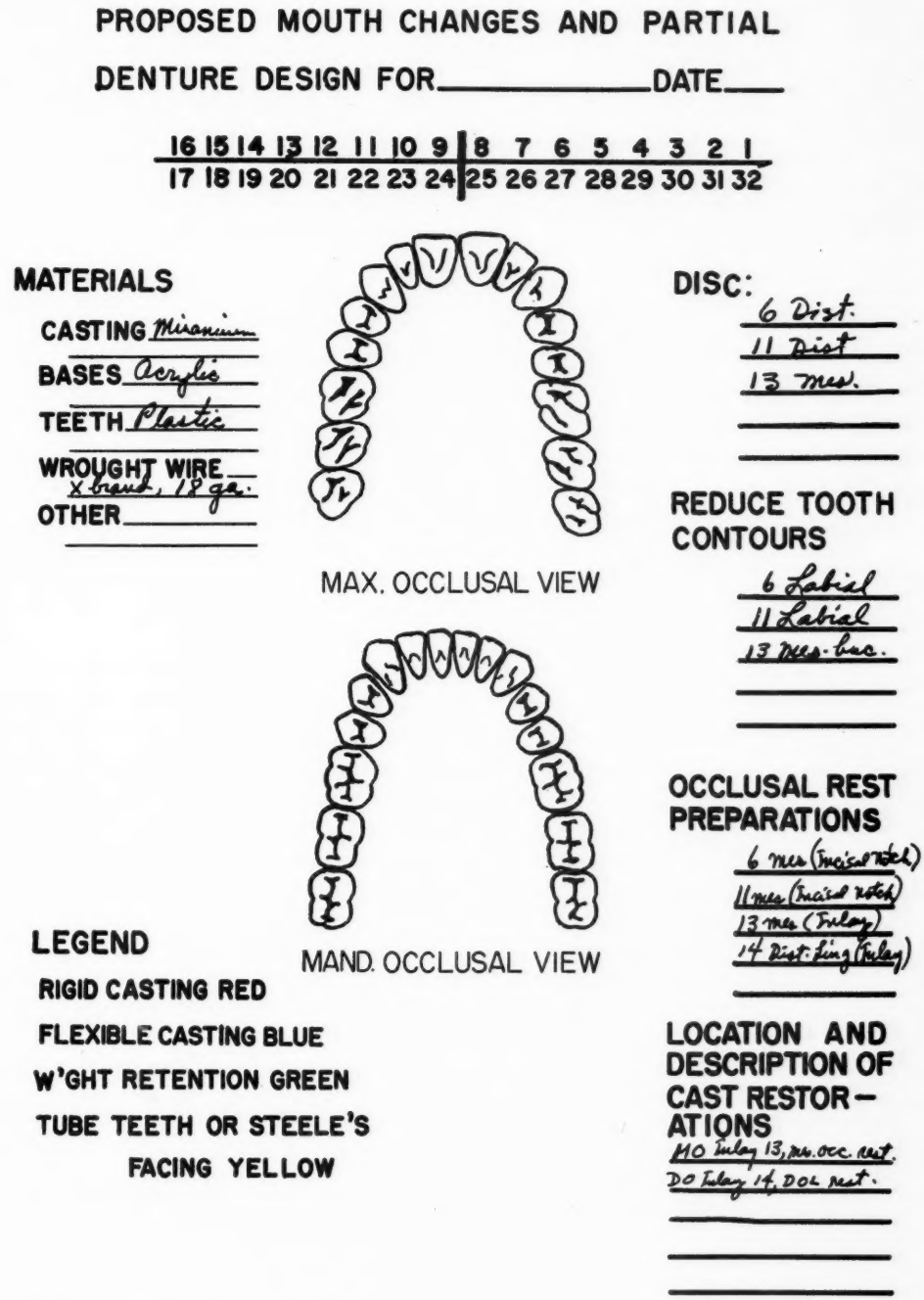

Fig. 2.—Chart for recording denture design, mouth preparations, and other information pertinent to the design of the partial denture.

Equipped with the study casts upon which a tentative partial denture design has been drawn (Fig. 3), the dentist is then able to accomplish mouth preparations with some degree of accuracy. The information at hand should include the areas of teeth to be disked and the tooth contours to be changed, the location of occlusal rests, the path of insertion, and the written comments of the technician. Only if the cooperation between technician and dentist is carried to this degree can the technician's survey of the dentist's study casts be of much aid to him in accomplishing mouth preparations.

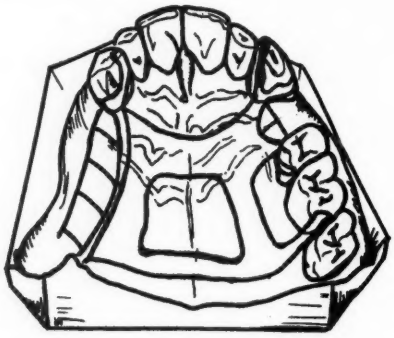

Fig. 3.—Study cast with a partial denture design outlined upon it.

Let me restate the preceding paragraphs in this manner. A survey of accurate study casts by the dentist in his own laboratory is the best way for mouth preparations to be planned with accuracy and carried out in the mouth with any degree of accuracy. Only because relatively few dentists are so equipped, or so inclined, do I suggest that a survey by the technician may be acceptable, and then only through the close cooperation and understanding of both parties concerned.

PROTECTION OF ABUTMENT TEETH BY FULL COVERAGE

During examination and subsequent treatment planning, in conjunction with a survey of study casts, each abutment tooth is considered individually as to whether or not full coverage is indicated. It cannot be denied that full coverage of all abutment teeth used for partial denture support affords the best possible protection. Placing ourselves in the position of the patient, we can better understand his reluctance to have what appears to be sound teeth mutilated for the purpose of placing full crowns. Many of us, as dentists, would object in like manner. Therefore, we must consider the alternatives to full gold crowns.

Abutment teeth presenting sound enamel surfaces, in a mouth where good oral hygiene habits are evident, may be considered a fair risk for partial denture abutments. One should not be misled, however, by a patient's promise to do better, so far as oral hygiene habits are concerned. Good or bad oral hygiene is a habit of long standing, and is not likely to be changed appreciably because a partial denture is being worn. Therefore, we must be conservative in evaluating the oral hygiene habits of the patient in the future. It is well to remember that clasps as such do not cause teeth to decay, and if the individual will keep the teeth and

partial denture clean, and has a low caries index, one need not condemn clasps from a cariogenic standpoint. More partial dentures have been condemned as cariogenic because the dentist did not provide for the protection of abutment teeth than because of inadequate care on the part of the patient. I am convinced of the fact that more full coverage of abutment teeth is indicated than we are prone to recommend.

Admittedly, the full-cast gold crown is objectionable from an esthetic standpoint, and therefore the porcelain-veneer type of full crown must be resorted to where a maxillary cuspid or bicuspid abutment is to be restored or protected. Rarely does the maxillary molar have to be treated in such a manner, and the full gold crown is acceptable.

In the mandibular arch, only a cuspid abutment will have to be covered with a porcelain veneer crown for maximum protection. The mandibular bicuspid crown can usually be made with an acrylic veneer over only the occlusal half of the buccal surface, leaving sufficient gold gingival to the veneer for gold support of the clasp arm (Fig. 4). This type of crown prevents a display of gold in the area most likely to be seen, and is somewhat simpler in construction than the porcelain veneer.

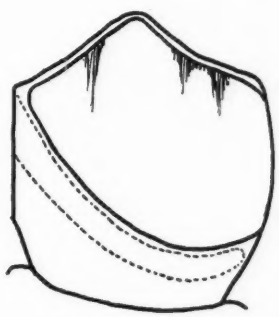

Fig. 4.—An acrylic veneer full crown for a partial denture abutment. Note the extent of the veneer, location of the clasp arm, and the distal guiding plane.

CAST GOLD INLAYS VERSUS AMALGAM RESTORATIONS FOR ABUTMENT TEETH

Where there is proximal caries on abutment teeth with sound buccal and lingual enamel surfaces, in a mouth exhibiting average oral hygiene and low caries activity, a cast-gold inlay is usually indicated. One should not condemn the amalgam filling for the restoration of proximal caries, although one must admit that an inlay casting of a hard-type gold will provide the best possible support for occlusal rests, at the same time giving an esthetically pleasing restoration. On the other hand, the modern amalgam restoration, properly condensed, is capable of supporting an occlusal rest without appreciable flow over a long period of time.

I would like to make a plea for wider coverage of proximal tooth surfaces where an inlay is to be used on an abutment tooth. The majority of box preparations with a gingival bevel are not extended sufficiently for maximum protection of the tooth. The most vulnerable area on the abutment tooth is the proximal

gingival area which lies beneath the minor connector of the partial denture framework, and is therefore subjected to the lodgment of debris and most vulnerable to caries attack.

Even when the partial denture is removed for purposes of cleaning the teeth, these areas, especially those on the distal of an anterior abutment, are often missed by the toothbrush, and bacterial plaques and debris are allowed to remain for long periods of time.

Except in a caries-immune mouth or in a mouth where the teeth are subjected to meticulous brushing, there is, inevitably, decalcification and caries attack in this region. It is necessary, therefore, that this area of the tooth be fully protected by whatever restoration is used. Where an inlay restoration is used, a slice preparation used in conjunction with a box, carried to or beneath the gingival margin, and well out onto the buccal and lingual surfaces affords the best inlay protection of the abutment tooth (Fig. 5, *A* and *B*). Even the full crown can be deficient in this most vulnerable area which lies at and just above the gingival margin. The full crown which is cast short of this vulnerable area will not afford protection where it is most needed.

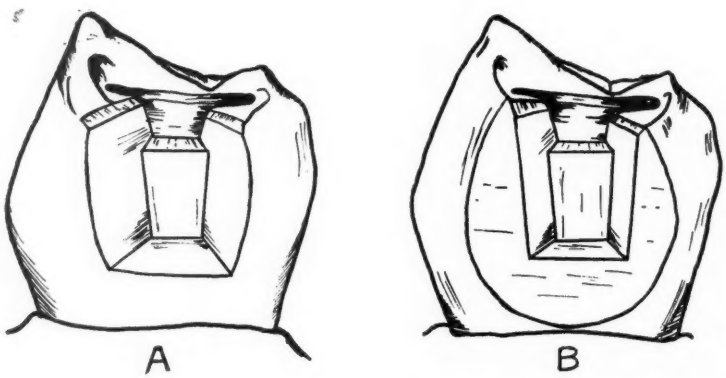

Fig. 5.—*A*, The outline form of a proximal inlay preparation which fails to provide for adequate protection of vulnerable tooth surfaces lying beneath the minor connector.

B, A modified slice inlay preparation which will best protect the proximal tooth surface beneath a minor connector. The slice should be carried far enough buccally and lingually to terminate on a free cleansing area, and should be carried just beneath the gingival margin if at all possible.

PARALLELING PROXIMAL TOOTH SURFACES FOR GUIDING PLANES

All proximal tooth surfaces which are to serve as guiding planes for the partial denture should be disked so as to be made as nearly parallel to the path of insertion as possible. This is accomplished on sound enamel or on existing restorations by disking those tooth surfaces parallel to the path of insertion, and the same can be done for the recently placed full crown or inlay.

Modern indirect techniques using hydrocolloid or the more recent rubber-base impression materials permit the contouring of wax patterns on the stone abutments with the aid of the surveyor blade. *All* abutment teeth to receive castings can be prepared at one time and an impression made which will provide an accurate

stone replica of the prepared arch. Separate individual dies, or removable dies, are made upon which the contoured wax patterns may be refined. All proximal tooth surfaces should be made parallel to the path of insertion by the use of the surveyor blade. This will provide proximal tooth surfaces which will be parallel without any further disking in the mouth, will permit the most positive seating of the partial denture along the path of insertion, and will provide the least possible space beneath minor connectors for the lodgment of debris.

OCCLUSAL REST SUPPORT

After the proximal surfaces of the wax patterns have been made parallel, and buccal and lingual contours have been established which will satisfy the requirements of retention with the best possible esthetic placement of clasp arms, the occlusal rests should be prepared in the wax pattern rather than in the finished gold restoration. The placement of occlusal rests should be considered at the time the teeth are prepared to receive cast restorations, so that there will be sufficient clearance beneath the floor of the occlusal rest. Too many times we see a completed gold restoration cemented in the mouth for a partial denture abutment without any provision for the occlusal rest having been made in the wax pattern. The operator then proceeds to cut an occlusal rest in the gold restoration being ever conscious of the fact that he may perforate the gold during the process of forming an occlusal rest. The unfortunate result is usually a poorly formed occlusal rest that is too shallow and one that does not incline toward the center of the tooth in the desired manner.

Fig. 6.

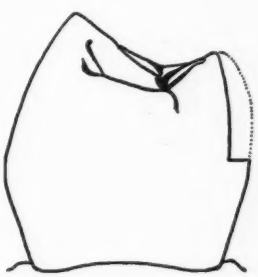

Fig. 7.

Fig. 6.—The outline form of an occlusal rest seat established in the wax pattern. The marginal ridge should be lowered, to accommodate the origin of the occlusal rest with the least occlusal interference without sacrificing bulk, and the seat should be essentially a half ball, with the deepest portion lying inside the lowered marginal ridge.

Fig. 7.—A lingual shoulder prepared in the wax pattern to accommodate a reciprocal arm contoured to the dotted line. This does not usually eliminate the need for an occlusal rest, but does substantially augment it.

If tooth structure has been removed so as to provide for the placement of the occlusal rest, the occlusal rest may be ideally placed in the wax pattern by using a No. 6 round bur to lower the marginal ridge and establish the outline form of the occlusal rest, and then using a No. 4 round bur to deepen slightly the floor of the occlusal rest inside of this lowered marginal ridge. This provides for an

occlusal rest which best satisfies the requirements of an occlusal rest preparation; that is, that the rest be so placed that any occlusal force will be directed toward the center of the tooth, and that there will be the least possible interference to occlusion with the opposing teeth (Fig. 6).

Additional support for the partial denture may be accomplished by forming a circumferential ledge on the lingual surface of the wax pattern which will receive the reciprocal arm (Fig. 7). This has the advantage of supplementing the occlusal rest with a lingual rest, and at the same time minimizing the amount of the lingual clasp arm that will be exposed to the patient's tongue. This may either be formed in the wax pattern or disked in the finished crown restoration prior to final polishing.

FUNCTIONS OF THE OCCLUSAL REST

A consideration of the functions of the occlusal rest will lead to a better understanding as to why an occlusal rest must be placed in the abutment tooth, and why its outline form must be meticuously executed. In a tooth-borne partial denture, where abutment teeth are available for support at each end of each edentulous area, the occlusal rest transmits *all* of the occlusal force coming upon the partial denture to the abutment teeth, just as surely as the occlusal forces coming upon the replaced teeth of a fixed bridge are transferred to the abutment teeth through a soldered union (Fig. 8).

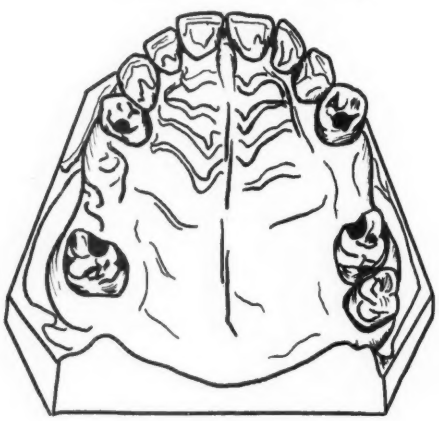

Fig. 8.

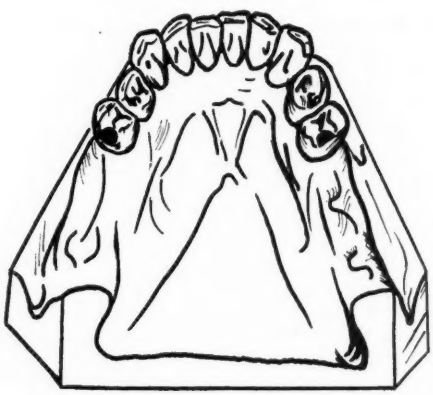

Fig. 9.

Fig. 8.—A Kennedy Class III (Modification 1) partially edentulous arch. Here the removable bridge type of partial denture is entirely tooth supported by means of four occlusal rests.

Fig. 9.—A Kennedy Class I partially edentulous arch. Here the true partial denture derives only a minor, and decreasing, support from the teeth as the denture base becomes more tissue borne toward the free end.

This type of partial denture, whether it be unilateral or bilateral, is, in effect, a removable bridge and is just as effective in restoring lost dental functions as a fixed bridge. In fact, a bilateral removable bridge can be more effective and better transmit occlusal stresses over a wider range of abutment support than two unilateral fixed bridges.

In the single or double free-end denture base type of partial denture, the occlusal rest can transmit only a portion of the occlusal forces coming upon the partial denture to the abutment teeth, that being those forces which come upon the denture nearest the abutment teeth (Fig. 9). The effect of the occlusal rest and the abutment supporting it diminishes as the occlusal force moves away from the abutment tooth toward the free end of the denture base. Therefore, the free-end type of partial denture is supported by both the abutment teeth and the tissues underlying the base and becomes more and more tissue borne as the distance from the abutment tooth increases.

In the all-tooth-borne partial denture, and with diminishing effect upon the tooth-tissue-borne partial denture, the occlusal rest also serves to prevent gingival displacement of the partial denture, maintains occlusal contact with the opposing teeth, protects the proximal gingival tissues from impingement and strangulation, and maintains the retentive terminal of the clasp arm in its intended position.

FORM OF THE OCCLUSAL REST

Perhaps the most important function of the occlusal rest is the division of stress loads coming upon the partial denture so as to provide for greatest efficiency with the least damaging effect to the abutment teeth. In order to do this, the occlusal rest must be able to transmit occlusal forces to the abutment teeth in an occlusal direction only, thereby permitting the least possible lateral stresses to be transmitted to the abutment tooth.

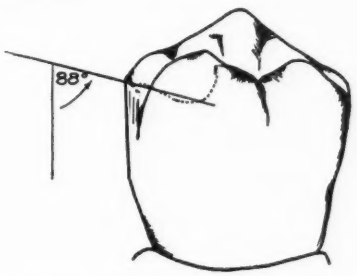

Fig. 10.—The floor of an occlusal rest preparation should incline toward the center of the tooth, forming an angle of something less than 90 degrees with the vertical minor connector. Note the guiding plane established on the proximal surface by judicious disking parallel to the chosen path of insertion.

For this reason, the floor of the occlusal rest should incline toward the center of the tooth so that the occlusal forces, in so far as possible, are centered over the root apex. Any other form but that of a spoon shape would permit a locking of the occlusal rest and the transmission of a tipping force to the abutment teeth as lateral stresses were applied. Boxlike occlusal rest preparations and those with vertical walls are to be avoided; a ball-and-socket type of relationship between occlusal rest and abutment tooth is the most desirable. At the same time, the marginal ridge must be lowered so that the angle formed by the occlusal rest with the minor connector will stand above the occlusal surface of the abutment tooth as little as possible, and create as little disharmony with the opposing teeth and present as little bulk to the tongue as possible.

Sufficient bulk must be provided for, however, to prevent a weakness in the occlusal rest at the marginal ridge. The marginal ridge must be lowered and yet not be the deepest part of the rest preparation, or an angle of greater than 90 degrees with the minor connector would be formed. To permit occlusal stresses to be directed toward the center of the abutment tooth, the angle formed by the floor of the occlusal rest with the minor connector should be less than 90 degrees. In other words, the floor of the occlusal rest inclines slightly from the lowered marginal ridge toward the center of the tooth (Fig. 10).

This proper form can be readily accomplished in the wax pattern if provision has been made during crown or inlay preparation to provide for the location of the occlusal rest. Where an amalgam restoration is used, there must be sufficient bulk in the amalgam restoration in this area to allow proper occlusal rest form without weakening the restoration. Where the occlusal rest is placed in sound enamel, it is best accomplished by the use of round diamond stones of approximately Nos. 4 and 6 diameters in the following sequence: first, the larger of the two diamonds is used to lower the marginal ridge and at the same time create the outline form of the occlusal rest. The result is an occlusal rest preparation, with marginal ridge lowered and gross outline form established, yet without sufficient deepening of the rest preparation toward the center of the tooth. The smaller diamond stone or a carbide bur of approximately No. 4 size may then be used to deepen the floor of the occlusal rest to a gradual incline toward the center of the tooth. Smoothing the enamel rods by the planing action of a round bur revolving at high speed with little pressure is all the polishing of the enamel surface that is needed.

Occlusal rest preparations in existing restorations, or on abutment teeth where no restorations are to be placed, should always follow, not precede, the disking of proximal tooth surfaces. The disking of proximal tooth surfaces should be done first, for if the occlusal rest is placed first and the proximal tooth surface is disked later, the outline form of the occlusal rest is sometimes irreparably altered.

Where an enamel defect is encountered in the preparation of an occlusal rest in tooth enamel, it is perhaps best to ignore it until the occlusal rest preparation has been completed, and then the defect remaining can be eliminated with small burs, and either a gold foil or an amalgam restoration placed and polished flush with the floor of the occlusal rest.

PREPARATION OF CUSPID TEETH TO PROVIDE OCCLUSAL REST SUPPORT

The preparation of cuspid teeth to provide occlusal rest support for a partial denture may be accomplished in one of three ways. If the lingual and proximal surfaces of the cuspid tooth are sound, and if the lingual slope of the cuspid is not too steep, an occlusal rest may be placed on the lingual surface of the cuspid just above the cingulum in much the same manner as a rest is placed upon an occlusal surface. The proximal marginal ridge is lowered and the deepest part of the occlusal rest lies inside of the marginal ridge. However, one must visualize

the path of insertion of the partial denture and must not make the mistake of preparing the lingual rest as though it were going to be approached from a direction perpendicular to the lingual slope. Rather, the incisal portion of the occlusal rest preparation must be so designed that no undercut of enamel lies in the path of insertion (Fig. 11,*A*).

This type of occlusal rest may frequently be used on the maxillary cuspid where the lingual slope is not too severe. Rarely, however, can this type of rest be utilized on the mandibular cuspid, because the lingual wall will be too steep. Here we are forced to resort to one of two other means for occlusal rest support on the cuspid. One is the placement of a three-quarter crown, so constructed that the cingulum has been raised or accentuated in forming the wax pattern, thereby providing for a definite cingulum rest. This need not be in the round form of an occlusal rest but may be in the form of a saddle upon which a lingual arm may rest (Fig. 11,*B*).

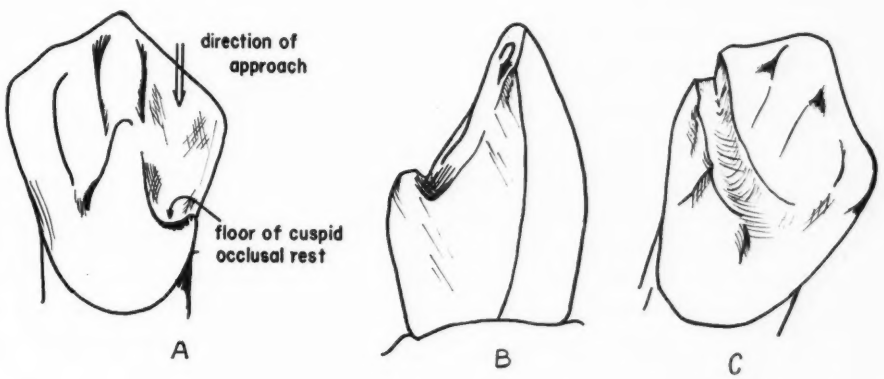

Fig. 11.—*A*, An occlusal rest preparation on the lingual surface of a cuspid tooth. This type of rest may be utilized only where the incline of the lingual surface is not steep and a definite cingulum exists. The mandibular cuspid will usually present too steep a lingual incline for this type of rest. Note the location of the rest seat and the removal of enamel to accommodate the incisal approach.

B, A cingulum rest on a cuspid three-quarter veneer crown. The cingulum must be accentuated in the wax pattern to provide a saddle rest. This type of rest should be placed as low on the tooth as possible yet should be so designed as to direct the forces toward the center of supporting root, thereby approaching what may be considered the most desirable occlusal rest support.

C, A slightly exaggerated rest preparation on a canine tooth, utilizing an incisal notch on the mesial-incisal angle. The 90 degree rest is feathered off in the direction of the lingual approach. Such an incisal rest does not display an objectionable amount of metal when finished flush with the surrounding enamel.

The other alternative is the preparation of a notch on the mesial incisal angle of the cuspid, which is approached from the distal across the lingual surface of the tooth (Fig. 11,*C*). This type of rest provides for definite support, little loss of tooth structure, and little display of metal. Esthetically, it is preferable to the three-quarter crown. The same criteria apply in deciding whether to use this type of rest in preference to the three-quarter crown as in deciding whether or not to use sound enamel support for an occlusal rest on a posterior tooth.

SUMMARY

The success or failure of a partial denture may well depend upon how well the preliminary steps were accomplished. These are: (1) diagnosis and treatment planning, utilizing to the fullest the dentist's own reservoir of knowledge and experience, the roentgenogram, the vitalometer, and the use of accurate study casts; (2) education of the patient through the use of study casts and x-ray view box; (3) intelligent survey of each partially edentulous arch, both before mouth preparation and after; and (4) carefully planned and executed mouth preparations, utilizing cast restorations wherever indicated, again with full use of the surveyor properly to contour wax patterns that will serve best to support and retain the finished appliance.

It is only through intelligent planning and competent execution of the many steps in the construction of a partial denture, in conjunction with the intelligent and informed cooperation of the patient in the maintenance of the appliance and the supporting teeth, that the partial denture can serve as more than a prelude to full mouth extractions, and become a respected device for the restoration of lost dental functions and the preservation of the remaining oral tissues.

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PRACTICAL APPLICATION OF ORAL PHYSIOLOGY

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IN ORAL DIAGNOSIS, we were taught to count cavities, chart them, note missing teeth to be bridged, count them, and then to examine the oral cavity for gross pathologic lesions of the soft tissues, all of the examining being done with an open mouth.

To verify the findings of this visual, digital, and instrument examination, and to disclose any additional cavities and pathologic condition of the roots and investing tissues, the pulp tester, transillumination light, and radiograph were used.

The tooth was examined, as an individual unit, for pathologic conditions alone, without regard for its function with its contacting and opposing teeth. If a case was unusual, "snap" impressions were sometimes made, from which casts were made to be articulated in the hand. The only thing that could be determined from the foregoing procedure was an approximate relationship of the two arches to one another. From this type of examination, only a cost diagnosis could be made for the application of the arts of the profession in making highly polished restorations for the missing parts of teeth and missing teeth, but without regard to function.

The resulting treatment is a failure because it does not include the practical application of oral physiology. The restorations made from this inefficient examination, therefore, will be biologically wrong.

It is a conceded fact in the medical profession that a complete examination and diagnosis is of the highest value to the patient. Many of our profession are negligent in this matter, because dental schools fail to stress this important phase of dentistry.

OBJECTIVES OF THE EXAMINATION

No other area in the human body presents more difficulties in diagnosis than the masticating mechanism. The objectives of an examination for the purpose of diagnosis and treatment planning should be: (1) to uncover any pathologic processes of the hard and soft tissues of the oral cavity, and (2) to uncover any predisposing factors or conditions which, if not corrected or eliminated, would lead to pathologic processes in the oral cavity.

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To accomplish this, we must consider the masticatory mechanism as a unit, and follow a careful plan of examination as follows:

1. Consideration of the patient's chief complaint.
2. Medical and dental history of the patient.
3. Clinical examination.
4. Radiographic examination.
5. Special diagnostic procedures which would include pulp testing, transillumination, and dietary control.
6. Properly mounted study casts.

In addition to the above, a study of the functional relationship that exists between the movable and fixed parts of the masticatory mechanism must be made. Each case has problems peculiar and distinctive to itself, and there are no "twins" in this matter.

When a patient presents himself for treatment at the Dental School of the University of Oregon, the first *five* steps are always completed. If it is determined from this examination that there may be any crowns, bridges, or occlusal rehabilitation work necessary, a staff member of the Crown and Bridge Department is consulted. The patient is then assigned to a student who must complete the examination by mounting accurate study casts of the mouth in the correct functional relation that the teeth bear to each other.

This enables us not only to instruct the student in oral physiology, but, also, to train him to make an adequate diagnosis before attempting any restorative work, whether it is a single crown or a complete functional rehabilitation of the chewing mechanism.

REFERENCE POINTS AND ORIENTATION

After obtaining accurate study casts, the student must locate and record the true hinge axis with a suitable hinge axis locator. From this he learns that the hinge axis is the vertical rotation of the condyle about an axis, that it is constant to the mandible, thus determining the arc of closure on which the teeth meet, and that the hinge axis is the point from which all of the functional paths of the mandible begin. This being true, he realizes that, for future reference, the hinge axis point must be permanently recorded with tattoo marks on the tissue opposite the rotational points.

We are then able to show him that, in order to use the face-bow transfer properly, he must have a third reference point at the base of the orbit to establish the axis orbital plane. The demonstrator then instructs the student to locate the inferior border of the orbit on the right side and, for convenience, to record this with a tattoo mark on the same plane on the side of the nose. From these reference points, the student is shown that, in addition to having located the hinge axis of the mandible, he has also established the axis orbital plane which, with the patient sitting erect and looking straight ahead, is parallel with the floor. His demonstrator can further show this plane on the articulator, and, by placing the instrument on a table top, that its axis orbital plane, too, is parallel to the floor. He can be shown also, that by utilizing the three recorded reference points on the patient, along with the face-bow transfer, he will be able at any time to

mount an upper cast of this patient to the same plane of occlusion. By transferring the face-bow to the mounting platform, the student is shown that he merely transferred readings from the patient to the instrument, and that the plane of occlusion on the instrument is the same as that of the patient.

CENTRIC RELATION

The demonstrator can now show the student how to orient the lower cast to the upper cast in the correct centric relation. By taking suitable interocclusal records on each side of the arch, the student is taught that centric relation is the most retruded position of the mandible, from which all functional movements start. With the aid of the interocclusal records, the mandibular cast is attached to the lower member of the articulator, in centric relation to the maxillary cast. By taking several interocclusal records, he is shown that centric relation is repetitive, and that it must be so in order to be accurate, and also that centric relation and centric occlusion are not always harmonious.

PROTRUSIVE RECORDS

Now the demonstrator can show the student how to take proper protrusive records and set the condylar path of the articulator to this recording. This, too, is rechecked for accuracy. At this time, the demonstrator shows that the protrusive records determine the condylar path, but, on the type of instrument being used, it is a straight path. However, the condylar path is never straight, since both condyles and menisci slide forward and down on the slanting curvature of the glenoid fossa.

The procedure of establishing the Bennett movement is demonstrated next. The student is told that, if the so-called centers around which the jaw rotates lie back of the hinge axis, there is a definite side shift of the condyles, which is termed the Bennett movement. If the rotational centers lie in the hinge axis, there is no side shift and thus no Bennett movement. If the resulting reading on the condyle posts is high, there is a large Bennett movement. However, if the reading is 0°, there is no Bennett movement.

CORRELATION OF OBSERVATIONS

With the casts properly mounted, the student can note the worn facets of the occlusal surfaces created by the disharmonies between centric occlusion and centric relation, and the stresses produced in the protrusive and lateral mandibular movements. By correlating and studying these findings in conjunction with the radiographs, he becomes aware of bone destruction produced by these disharmonies.

From the parade of evidence produced in mutilated mouths with worn cusps, battered, mobile, and missing teeth, gingival pockets, and bone destruction, the student can realize that the mandible holds to its condylar pattern without influence from the masticating muscles or tooth form, and that the temporomandibular joints control its movements. He knows also, that he can check the patient's occlusion adequately on the instrument without interference from saliva, tongue, or cheeks, and that the mouth is not the place to study jaw function.

Now it can be shown that the factors utilized in properly orienting the casts were all fixed factors which cannot be changed or altered. It can be demonstrated to the student that, although these factors are fixed, nevertheless, there are other factors that *can* be altered to restore the mouth to normal function.

The student may find, in some patients, that by careful selective grinding, physiologic function is aided to such an extent that the patient can be greatly benefited, and the restorations placed will be biologically sound.

In other patients, where the occlusion is badly broken down, the student will find it necessary to change the alterable factors, such as the occlusal plane, curve of Spee, cusp inclination, and incisal guidance to restore physiologic function. This will be determined by prewaxing the study casts to the correct biologic occlusion before completing the diagnosis.

By correlating these factors along with the clinical findings, the student is in a position to render an adequate diagnosis for the patient, and, at the same time, show the patient what can be done to restore normal function, preserve the teeth, and minimize future pathologic difficulties due to occlusal disharmonies.

I would like to pay tribute to Dr. B. B. McCollum for the fine work he and the members of the Gnathological Society have done in their study of the mandibular movements and condylar function. From their work, the Gnathoscope evolved, and only on this instrument can the mandibular movements be reproduced accurately. This has been a great benefit to the profession and to the patients as well.

Although we believe that the movements of the mandible can be reproduced only on the Gnathoscope, we feel that the application of these principles to an instrument, such as the modified Hanau or Dentatus, will enable the student to closely approximate these jaw movements and to study thoroughly the oral physiology of each of his patients.

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THE THREE DIMENSIONS IN THE OCCLUSAL FORMS OF TEETH

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INSTEAD OF ARBITRARILY deciding what the masticating surfaces for a given patient should be, let us consider some of the factors involved. If chewing were simply a matter of opening and closing in centric position, flat occlusal surfaces would seem to be adequate (Fig. 1). There is simultaneous contact between upper and lower surfaces, and the forces are distributed over the available bearing area (Fig. 2).

We know, from observation, that when food is introduced into the mouth the mandible moves into a protrusive position. This is an instinctive attempt on the part of the patient to transfer the food from the anterior to the posterior part of the mouth for the actual chewing. We have observed, also, that in taking the centric wax maxillomandibular records, patients will give us a protrusive record more often than not, unless they are restrained from doing so.

MANDIBULAR MOVEMENT IN TWO DIMENSIONS

The way in which the mandible will move is determined at its posterior ends by the condyle paths, and at its anterior end by the anterior guidance. If the anterior guidance is zero and the mandible moves into a protrusive position, simultaneous uniform contact between the upper and lower surfaces is lost, and the closing forces are concentrated in the anterior region. Space is created between the upper and lower members posteriorly (Fig. 3). If flat occlusal surfaces were set on a curve instead of a plane, the same would occur in protrusive positions except that the forces would be concentrated in the posterior region as a result of the posterior contact (Fig. 4). This space between upper and lower occluding surfaces should be "taken up" with cusps, provided we are to make an attempt to maintain uniform simultaneous contact. Teeth that occlude properly are teeth that maintain uniform simultaneous contact in all possible contacting positions within their functioning range (Figs. 5 and 6).

MANDIBULAR MOVEMENT IN THREE DIMENSIONS

If we amplify what we see in two dimensions to include the third dimension and the movement involved (the lateral positions), the condyle path and the anterior guidance in protrusive positions will be different than the condyle path and anterior guidance in lateral positions. Therefore, the space created between upper and lower occlusal surfaces in lateral positions will differ from that in protrusive positions. As a result, the amount of occlusal curvatures will differ from

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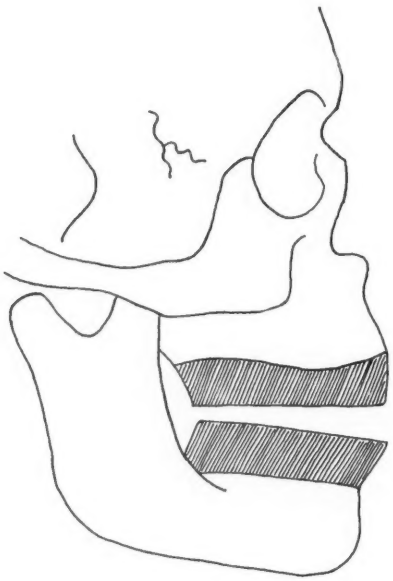
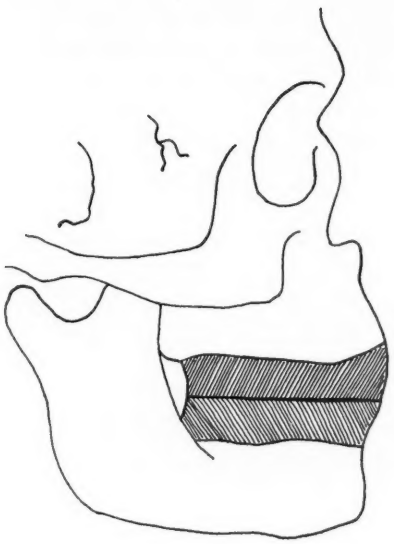


Fig. 1.



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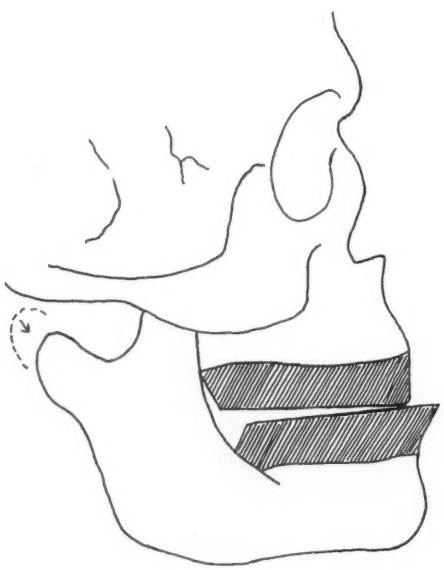

Fig. 3.

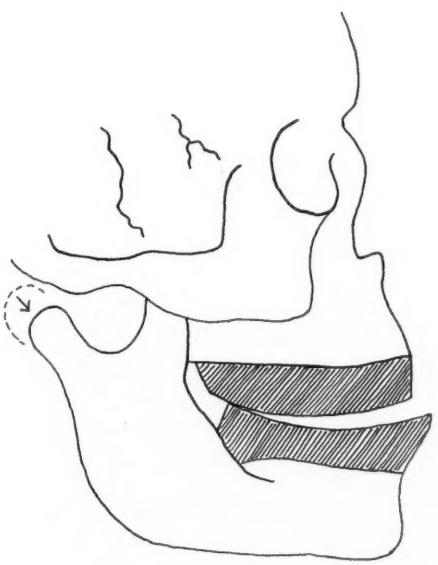

Fig. 4.

Fig. 1.—Occluding surfaces in the open position in a centric relation.
Fig. 2.—Occluding surfaces in the closed position in centric relation.
Fig. 3.—Flat occlusal surfaces set on a flat plane in a protrusive position.
Fig. 4.—Flat occlusal surfaces set on a curve in a protrusive position.

those required in protrusive positions. The factors which determine the height, form, and position of cusps are the condyle path, the Bennett movement, plane of occlusion, compensating curve, and the anterior guidance. Changing any one of these factors produces a change in the net result.

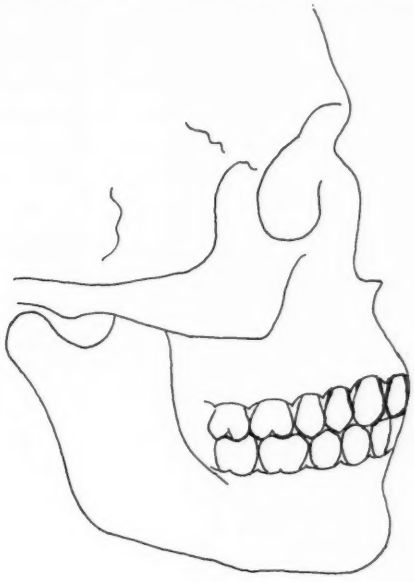

Fig. 5.

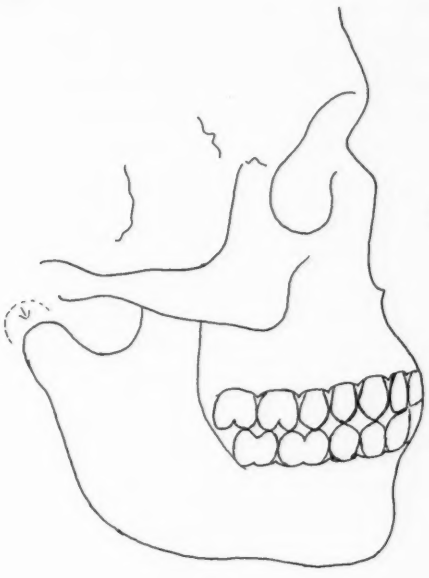

Fig. 6.

Fig. 5.—Continuous contacts of teeth with cusps in centric position.
Fig. 6.—Continuous contacts of teeth with cusps in a protrusive position.

PRELIMINARY CONSIDERATIONS

How does one go about creating these cusps? We will assume that we have an articulator adjusted to the mandibular movements of a specific patient. The casts are properly mounted in the articulator. The mandibular movements we will refer to are the straight protrusive, the working movement, and the lateral protrusive bisecting these. On the opposite side we have the balancing movement; bisecting that and the straight protrusive movement, we have the lateral protrusive movement. These are the basic mandibular movements.

We are considering the theoretical, ideal case, that is, the teeth are in their proper vertical relation. Most of the occlusal surfaces of the teeth have been removed as the result of inlay preparations; for practice carving, the occlusal surfaces may be removed completely. For the sake of sequence, we will confine this discussion to the teeth of one segment of the arch, namely, the upper first and second bicuspids and the lower second bicuspid on one side.

THE WAX PATTERN

A cone of hard inlay wax is formed, the tip of which will represent the tip of the lower second bicuspid. Its height will occupy one-half of the space that exists between upper and lower casts when the articulator is moved just to the end of the functional range of the lateral protrusive path on the working side. Then a cone

of wax is formed to represent the tip of the buccal cusp of the upper first bicuspid. While it is still soft, the articulator is closed at the end of the functional path of lateral protrusive movement so that the preformed tip of the lower cusp will form the tip of the upper cusp. The excess wax is chilled and carved away (Fig. 7 *a-b*). The lateral protrusive position is selected as the place to begin because it places the buccal cusps in the highest position to which they will rise. In other words, the greatest separation that occurs between upper and lower occluding surfaces on the working side is in lateral protrusive position. This separation dictates the height of the buccal cusps.

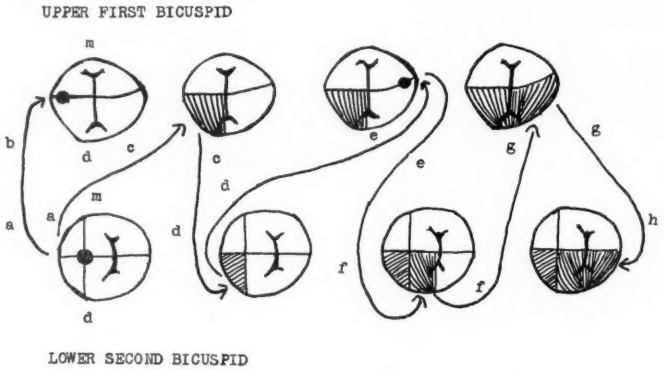

Fig. 7.—The sequence for creating cusps in wax.

Next, wax is added in the area of the buccolingual curve of the buccal cusp of the upper first bicuspid. While the added wax is still soft, the articulator is closed in lateral protrusive position on the working side, and moved in a circular fashion in the end ranges of both lateral protrusive and straight protrusive movements. This is done so the already determined tip of the lower second bicuspid will create the buccolingual curve of the buccal cusp of the upper first bicuspid on the working side in the soft wax. This parabolic buccolingual curve diminishes in height from buccal to lingual. The excess is chilled and carved away. Now wax is added in the remaining distal inner slope of the upper buccal cusp (Fig. 8). While the wax is still soft, the articulator is closed in centric position and moved into lateral protrusive position, returned to centric position and moved into the straight protrusive position, and returned again to centric position. The excess wax is wiped away by the movement into the working positions. The tip of the lower buccal cusp forms the distal half of the upper buccal cusp (Fig. 7, *a-c*).

Returning to the lower bicuspid, wax is placed in the area of the mesial outer slope of the buccal cusp. Before the wax hardens, the articulator is closed so there is tip-to-tip contact of the upper and lower buccal cusps. Then the articulator is moved toward centric position following the lateral protrusive path. It is then moved from centric position into the straight protrusive position, and returned again to centric position and moved into the working position to wipe away any excess wax. The distal half of the upper buccal cusp of the upper first bicuspid forms the mesial outer slope of the buccal cusp of the lower second bicuspid (Fig. 7, *c-d*).

A cone of wax is formed, the tip of which will represent the tip of the lingual cusp of the upper first bicuspid. While the wax is still soft, the articulator is closed at the end of the functional range of the balancing movement so that the buccal tip of the lower second bicuspid will create the tip of the lingual cusp of the upper first bicuspid. The wax is chilled and the excess is carved away (Fig. 7, *d-e*). The highest point to which the buccal cusps of the lower bicuspids and lingual cusps of the upper bicuspids will rise is in the balancing position. In other words, the space between the maxillary and mandibular occluding surfaces will be the greatest at the end of the functioning range of the balancing movement.

Now wax is placed in the area of the mesial inner slope of the buccal cusp of the lower second bicuspid (See Fig. 8). The articulator is closed in the balancing position and moved into centric position, then into straight protrusive position and returned to centric position, and moved into lateral protrusive position. The tip of the lingual cusp of the upper first bicuspid creates the convex curvatures of the mesial inner slope, as well as the marginal ridge, of the lower second bicuspid in the soft wax as it moves through these functional ranges (Fig. 7, *e-f*).

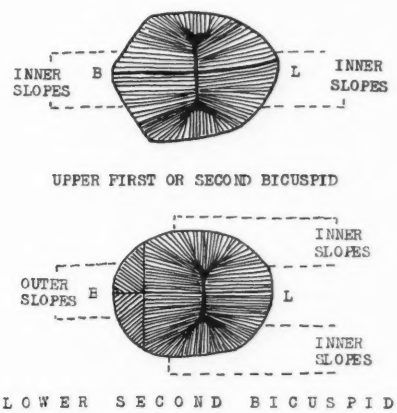

Fig. 8.—Occlusal curvatures which slope toward central sulci of the tooth are referred to as inner slopes; those which slope away from central sulci are referred to as outer slopes.

Wax is added in the area of the buccolingual curve of the lingual cusp of the upper first bicuspid. Before the wax becomes hard, the articulator is closed in the balancing position, and moved in a circular fashion through the end ranges of lateral protrusive and straight protrusive positions so that the tip of the lower buccal cusp of the lower second bicuspid will determine the buccolingual curve of the lingual cusp of the upper first bicuspid. It is obvious that the experienced operator may combine some of these operations into a single operation. I have purposely made subdivisions in order to establish boundaries, and to portray the way in which cusps work with each other.

Wax is flowed into the remaining area of the distal inner slope of the upper lingual cusp. The articulator is closed in the balancing position, moved to centric position, then to lateral protrusive position, returned to centric position, and moved into straight protrusive position. The tip of the lower buccal cusp, as it moves in

all its functional paths pushing excess wax ahead of it, tailors the distal half of the upper lingual cusp (Fig. 7, *f-g*).

The next step is simply a matter of flowing wax into the area of the mesial half of the lingual cusp of the lower second bicuspid. Before it chills, the articulator is closed in centric position, and moved into the working position. The same is repeated for the lateral protrusive and straight protrusive positions and movements (Fig. 7, *g-h*). We have thus far completed the distal half of the occlusal surface of the upper first bicuspid and one-half of the mesial side of the occlusal surface of the lower second bicuspid.

All of the foregoing procedures are repeated with the upper second bicuspid and the lower first molar. This creates the distal half of the buccal and lingual cusps of the upper second bicuspid (Fig. 9, *i*), as well as the mesial half of the buccal and lingual cusps of the lower first molar (Fig. 9, *j*). Likewise, the tip of the lower first bicuspid forms the distal half of the upper canine tooth. The distal slant of the lower second bicuspid is carved down to meet the base of the mesial slant of the lower first molar (Fig. 9, *j*). Wax is placed in the area of the mesial half of the buccal cusp of the upper second bicuspid, the articulator is closed in centric position, moved into the working position and the excess is carved away (Fig. 9, *j-k*). Wax is flowed on the distal outer slope of the lower second bicuspid, and, before it hardens the articulator is moved into the working position. The mesial half of the upper second bicuspid thus forms the distal outer slope of the lower bicuspid (Fig. 9, *k-l*). Wax is added to the mesial half of the lingual cusp of the upper second bicuspid, and, while it is still soft, the articulator is closed in centric position and moved into the balancing position. It is in this manner that the distal outer slope of the lower buccal cusps forms the mesial half of the upper lingual cusps as they glide by on their trip from centric position out to the balancing position (Fig 9, *l-m*). It will be noted that the mesial halves of the upper cusps and the distal halves of the lower cusps are in function only in the working and balancing movements. Any of the protrusive movements take these surfaces out of contact.

To complete the occlusalography of the lower second bicuspid, wax is added in the remaining occlusal areas, and, while it is soft, the articulator is closed in centric position and then moved into the balancing and working positions (Fig. 9, *m-n* and *m-o*).

All of the buccal and lingual cusps of all of the teeth are developed in the same manner, with the exception of the mesiolingual cusp of the upper first molar and the fifth cusp of the lower first molar. The mesiolingual cusp of the upper first molar passes through the sulcus between the distobuccal cusp and the fifth cusp of the lower first molar in the balancing movement. The fifth cusp of the lower first and second molars must be formed in conjunction with the mesiolingual cusp of the upper molars. The mesiolingual cusp is preformed. We know it occupies about two-thirds of the lingual area of the tooth. When viewed from the buccal aspect of the tooth, its tip is located between the buccal cusps. The mesiolingual cusp of the upper first molar is chilled, and wax is placed in the area of the fifth cusp of the lower first molar. While the wax is soft, the articulator is closed in centric position and moved into the balancing position to create the sulcus. Then it is

returned to centric position and moved into lateral protrusive position. The articulator is opened, then closed in centric position and moved into straight protrusive position. This forms the fifth cusp. If the upper lingual cusp has wiped away most of the wax intended to be the fifth cusp of the lower first molar, it is necessary to reduce the size, or relocate the tip, of the mesiolingual cusp of the upper first molar (Fig. 10).

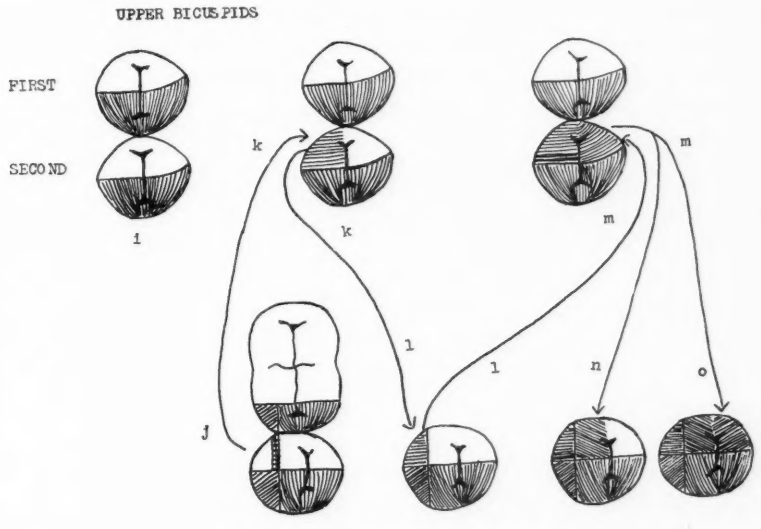

Fig. 9.—The sequence for creating cusps in wax (continued from Fig. 7).

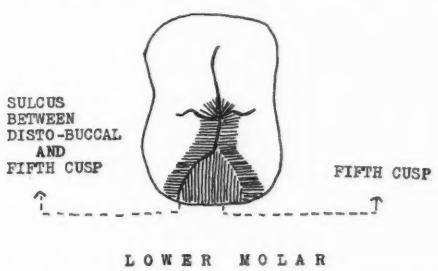

Fig. 10.—Forming the fifth cusp of the lower molar.

After the form of the cusps has been created, the sulci are carved. The cusp surfaces are not flat planes with surface-to-surface contact, they are parabolic in form, and make point contacts with each other. The cusps, when finished, are to fit into their corresponding sulci and fossae in a manner similar to the way in which ball bearings contact each other. They should not resist eccentric movement by being locked into each other, nor should they have a loose, sloppy, unsupported fit.

THE PORCELAIN TOOTH

The occlusal surfaces of porcelain teeth are sculptured in a similar manner, except, of course, with porcelain we can only remove, we cannot add to as we can

with wax. We start with an overamount of bulk, and carve it into the shape that is dictated by the adjusted articulator. We select posterior stock teeth of a large size with deep sulci. The teeth have been set on their bases, and esthetics and centric relation have been established. After the bases have been returned to the articulator, all the lower posterior teeth are removed. Then they are returned to it one at a time. The carving is completed on each one before the next tooth is set. To start, the articulator is locked in the lateral protrusive position on the working side. The lower second bicuspid is set so there is tip-to-tip contact of its buccal cusp with the buccal cusp of the upper first bicuspid and at the same time, of course, the incisal pin must have contact with the incisal plate. At this point it is wise to determine if there will be sufficient height of porcelain so that the tip of the lingual cusp of the upper tooth and the tip of the buccal cusp of the lower tooth will make contact in the balancing position. Assuming that this contact is established and that the incisal pin contacts the incisal guide, the articulator can be returned to the lateral protrusive position on the working side where it was set originally. The articulator is allowed to move slightly along the lateral protrusive path toward centric position. It is probable that, on checking the incisal pin, it will be out of contact with the incisal guide. A prematurity of contact is indicated by this. Using hard, thin, articulating paper, the teeth are tapped together to locate the point of contact. The tip of the buccal cusp of the lower second bicuspid should not be reduced. Rather, the tailoring will be started on the distal inner slant of the buccal cusp of the upper first bicuspid because the tip of the lower cusp has been fixed or established. The lateral protrusive path, which the tip of the lower cusp follows as it travels upon the upper cusp moving toward centric position, is being tailored. Simultaneously, it is also necessary to begin tailoring the lateral protrusive path of the lingual cusp of the upper first bicuspid as it moves toward centric position. The tailoring here is, of necessity, done on the lower cusp because the tip of the upper cusp has been determined previously. The same sequence of movement and modification is followed for porcelain as for wax, but, as noted above, the buccal and lingual cusps are tailored simultaneously.

COMMENTS

There is no way of telling beforehand what cusps are required for a given patient without following this sequence or one similiar to it. These cusps do not guide the mandible, rather they are synchronized with the movements of the mandible.

It is not likely that the beginner will grasp the intricacies of arranging and modifying teeth from a word picture alone. It is suggested that it be accompanied by study or enlarged plaster models of the upper first and second bicuspids and the lower second bicuspid. A set of maxillary and mandibular casts or models of a theoretically ideal occlusion would also be a helpful adjunct to learning.

The author is indebted to Dr. Ernest R. Granger of Mt. Vernon, N. Y., for the routine of carving described herein.

420 Johnson St.
Freeland, Pa.

A HYDROCOLLOID TECHNIQUE FOR PINLEDGE BRIDGE ABUTMENTS

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Paterson, N. J.

ESTHETICS IS AN IMPORTANT factor in determining the type of attachments to be used in anterior fixed bridgework. Wherever the natural appearance of the labial enamel can be preserved, it is advantageous to do so.

Full tooth coverage is necessary in many cases: in caries-susceptible mouths, in teeth with large interproximal fillings, missing incisal angles, or eroded or carious labial surfaces. Some type of veneer crown must be resorted to in these situations. In a clean environment, however, sound teeth are favorable for pinledge attachments, and these should be the attachments of choice.

I have had gratifying success with pinledge bridgework for a period of over thirty-five years. Now, the hydrocolloid impression materials have simplified the technique, speeded up the work, and have proved more accurate and dependable than the older methods.

The pinledge bridge in Fig. 1 was constructed thirty years ago. It has never been removed or repaired. The right lateral pontic is carried by pinledge attachments in the central incisor and cuspid. The pins are of iridioplatinum wire, and the pattern was made directly in the mouth and cast in soft gold. The soft gold has taken a beating through the years, but the fact of the survival of the bridge should suggest that the engineering principle of the pinledge attachment is sound.

Some failures of pinledge attachments are admitted, and probably they are due to faulty margins and loose-fitting wire pins. With the hydrocolloid technique, it is possible to make cast gold attachments which fit with the precision of good inlays. They have the added advantages that a minimum of tooth cutting is required, and the gold can be hidden from sight and need not even affect the color or natural appearance of the abutment teeth. Fig. 2 shows a bridge made with the hydrocolloid technique where, in spite of extreme protrusion and fanning of the abutment teeth, it was possible to parallel six pinholes and carry the right central incisor without showing gold. Due to the gum recession and the divergence of the abutment teeth, veneer crowns would have been difficult and unsightly in this situation.

Pinledge attachments are useful for lower anterior bridges, and are handled the same as for upper bridges except that a contra-angle handpiece is used. Also, pin holes in lower incisors are usually cut with a Busch bur No. 699 which is

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slightly smaller than a No. 700 bur. The depth of the pin holes varies with the size and condition of the tooth, but it can be gauged best by the length of the cutting head of a No. 700 Revelation bur. The bur head is allowed to penetrate from one-half to three-fourths (in rare cases) of its length (Figs. 3 and 4). In spite of a hard bite and considerable overlap, this bridge has stood up for a number of years, and I expect it to do so indefinitely.

Fig. 1.

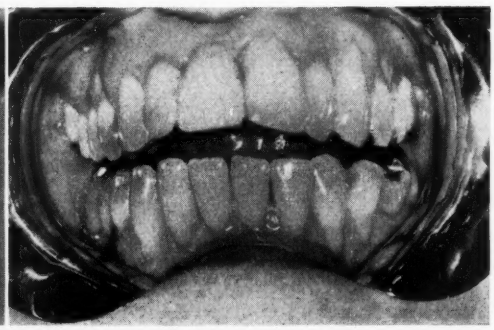

Fig. 2.

Fig. 1.—A bridge with pinledge attachments supplying the right lateral incisor. This bridge has been in service thirty years.

Fig. 2.—A bridge which supplies the right central incisor by means of pinledge attachments made by the hydrocolloid technique.

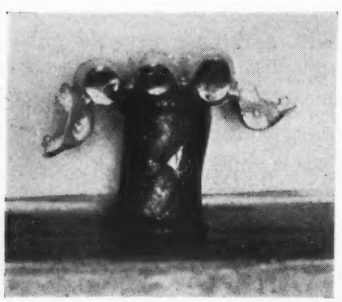

Fig. 3.

Fig. 4.

Fig. 3.—A lower anterior bridge with pinledge attachments. Note that the ends of the pins are flat like the end of the bur which cut the pin holes. This proves that no air was trapped in the pin holes.

Fig. 4.—The same bridge in the mouth. Note the extreme angle between the cuspid abutment and the pontic which accounts for the gold showing in the cuspid tooth.

The hydrocolloid technique was used for a patient who had extensive lingual wear and erosion on the upper teeth (Figs. 5, 6, and 7). The roentgenograms showed long healthy roots with good bone support and the loss of tooth structure in the coronal portion of the teeth. The use of veneer crowns here would have required cutting away most of the sound tooth structure remaining in the crowns of the abutment teeth. Pinledge preparations were made quickly as very little cutting was required. The impression was easily accomplished with hydrocolloid,

and the bridge was completed on the stone cast (Fig. 6), and inserted at the patient's second appointment (Fig. 7). This time-saving feature is routine on all pinledge bridges, and is made possible by the extreme accuracy of the hydrocolloid and stone-cast technique.

Fig. 5.

Fig. 6.

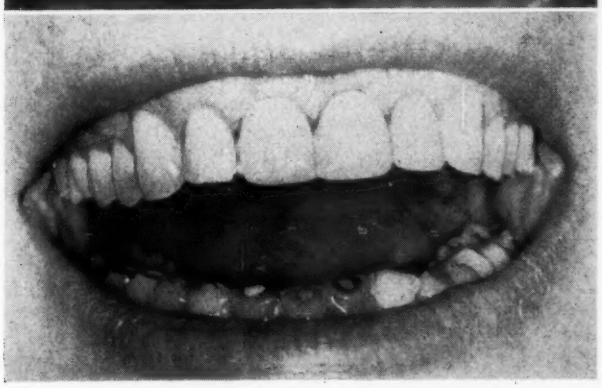

Fig. 7.

Fig. 5.—Roentgenograms of the abutment teeth.
Fig. 6.—The stone cast showing the preparations.
Fig. 7.—The completed restoration.

It is assumed that the reader is familiar with the hydrocolloid material and its use in inlay and bridgework. The main problem in applying the hydrocolloid technique to pinledge abutments is to avoid trapping air in the pin holes. Obviously, we must start injecting the material at the *bottom* of the pin holes.

THE NEEDLE

The smallest needle for the Thompson syringe (21 gauge) is not small enough to pass freely to the bottom of a pin hole made with a No. 700 bur. So it was necessary to modify this needle (Figs. 8, 9, and 10). With a knife-edge stone or diamond, the needle was circumscribed about halfway from shank to tip, and the tip was broken off. The end of the needle was smoothed with a fine paper disk, and the roughness was removed from the inner edge of the lumen with a

Fig. 8.

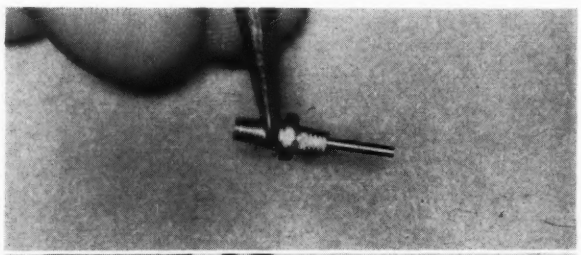

Fig. 9.

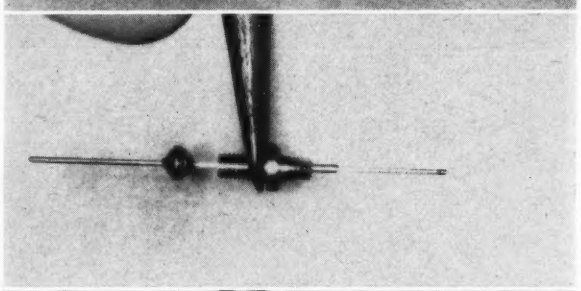

Fig. 10.

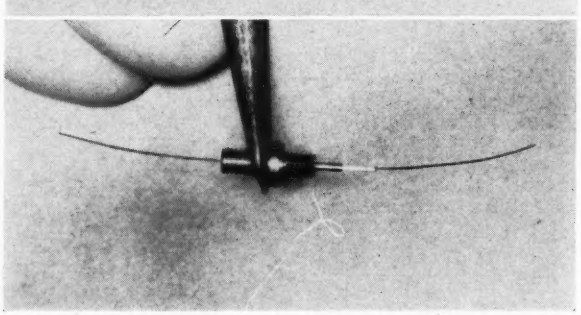

Fig. 8.—A 21 gauge needle on a Thompson syringe.

Fig. 9.—The needle is cut off and a 25 gauge carpule syringe is telescoped into the Thompson needle.

Fig. 10.—The 25 gauge needle is cut to the length that restores the original length of the Thompson needle. Note the wire in the lumen of the needle to make sure it is clean and open.

small flame-shaped finishing bur. A 25 gauge carpule needle which would telescope snugly within the cut-off 21 gauge needle was selected (Fig. 9). The carpule needles vary in their outer circumference, and it is possible to select one which virtually wedges in the larger needle (Fig. 9). The carpule needle was cut off so that it restored the length of the original needle. It could not be longer than the original needle or the needle screw cap would not fit over it. When the lumen of the small needle was checked to be sure it was clean and smooth (Fig. 10), the modified needle was screwed into the syringe and it was ready for use.

THE IMPRESSION

Not all hydrocolloid preparations are fluid enough at 150 degrees to flow freely through a 25 gauge needle. We have used for this purpose, Deelastic Special* which is more dilute than the regular hydrocolloid. Sometimes the needle will clog in the middle of an injection. Should this happen, we quickly pass a needle wire or fine broach through the needle, and continue injecting immediately.

For demonstration purposes, we have made pinledge preparations on a typodont, using the three adjoining anterior teeth (Fig. 11). The pin holes are filled first, starting at the bottom and injecting as the needle is withdrawn. This is done in an orderly manner, as rapidly as possible, but care is taken not to overfill the pin holes. The material is not adhesive, and the weight of excess bulk in upper teeth may permit gravity to pull the material out of the pin holes. Should

Fig. 11.

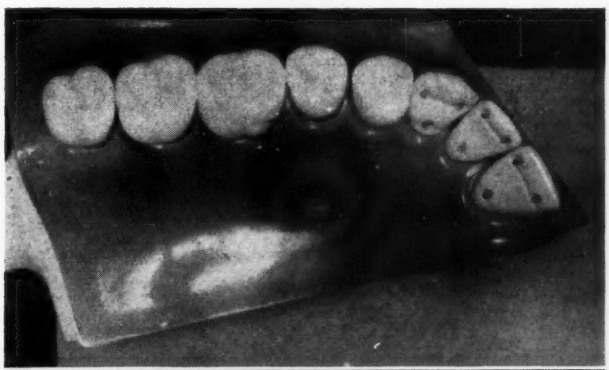

Fig. 12.

Fig. 11.—A typodont with pinledge preparations made in three teeth.
Fig. 12.—A stone cast made in a hydrocolloid impression.

excess be injected accidentally, it should be wiped off promptly with the finger. After all the holes and seats are filled, another syringe with a larger-gauge needle is used to inject the gingival trough, locking the material in the interproximal spaces and over the incisal edges to prevent gravity from displacing it. Then the previously filled tray is removed from the tempering bath, the surface water wiped off with the finger, and the tray is pressed to place. It is held firmly with the wax stops against the teeth and chilled for four or five minutes. In our experience,

*Kerr Manufacturing Company, Detroit, Mich.

chilling with cold water or ice water is *not* contraindicated. It is important, however, that the material be completely jelled, and that the cast be poured with reasonable promptness after the impression is removed from the mouth. It must be realized that the material is a poor conductor of heat, and where protuberances or extensions are present (such as the material extending into the pin holes), extra time must be allowed for complete gelation.

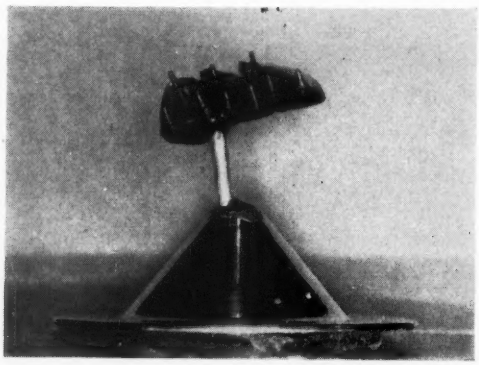

Fig. 13.—The wax pattern sprued for casting.

Fig. 14.

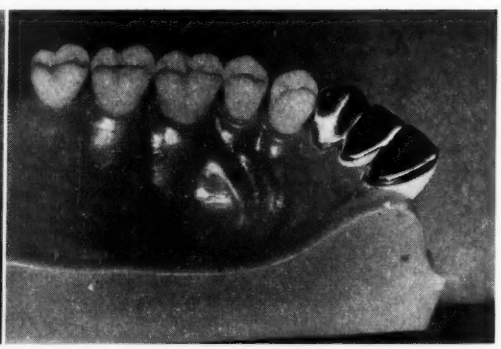

Fig. 15.

Fig. 14.—The casting in position on the stone cast.
Fig. 15.—The casting in position on the typodont.

THE CAST

The cast is poured in a hard stone, such as, Kerr's* Vel Mix and Ransom and Randolph's† Duroc. One hour is required for setting of the stone before the impression may be removed safely (Fig. 12). During this time, it should be kept in a humidor or immersed in water.

If the hydrocolloid breaks off in the pin holes when the impression is removed from the cast, *no attempt to remove it may be made until it has dried.* When the hydrocolloid is dry, it will shrink and harden, and then it can be easily picked or blown out without damage to the cast.

*Kerr Manufacturing Company.
†The Ransom & Randolph Co., Toledo, Ohio.

THE WAX PATTERN

The wax pattern is made by melting inlay wax over the well-lubricated stone cast, and driving it into the pin holes with a very hot pointed instrument, such as an old explorer point. The trapped air will bubble through the melted wax, and a dense smooth wax pattern can be removed from the stone cast with surprisingly little difficulty (Fig. 13).

CASTING AND FITTING

A very hard gold, such as Ney Oro G-3, is used for casting pinledge attachments, as I wish to avoid stretching or bending of the casting. This is in direct contrast to the soft golds which I used in the early years.

The castings must be fitted carefully on the stone cast. If they do not seat themselves when the cast is tapped gently on the laboratory bench, they are removed, and examined for minute defects, such as small bubbles or turned edges, and corrected. When the castings can be seated accurately on the stone cast *without force* (Fig. 14), they will fit in the mouth or on the master cast with the same accuracy (Fig. 15).

This demonstration is a severe test of the hydrocolloid and stone-cast technique, and it should be convincing evidence of its accuracy, its simplicity, and its usefulness in this field of dentistry.

44 Church St.
Paterson 1, N. J.

REVERSIBLE HYDROCOLLOIDS IN THE CONSTRUCTION OF THE UNIT-BUILT PORCELAIN BRIDGE

ARTHUR EDWARD KAHN, D.D.S.

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IN CROWN AND BRIDGE prosthodontics, the unit-built porcelain bridge is one of the most difficult constructions to make. This restoration has no equal, esthetically, but much can be said regarding its relative values when compared with cast veneer restorations in respect to marginal adaptation and over-all accuracy. The beauty created is of no value if it is doomed to failure within a relatively short time because of defective margins and breakage.

Anyone with some experience in this field of ceramics knows the truth of these statements. One has but to go through the many complicated phases of procedure necessary to produce the finished bridge to realize the shortcomings involved. Too often, as each bridge is completed, it is hoped that changes or an entire reconstruction will not have to be made. Further, there is the often recurring experience of finding that the gold framework fits (so far as alignment is concerned), but unfortunately, one or more margins of the copings may be short. Then, too, the margins may be correct, but the alignment incorrect; or copings may not fit at all. Among other possibilities, the framework may fit beautifully, but the jacket crowns may be incorrect at their margins or esthetically. It would be both senseless and elementary to review all the possible shortcoming of this type of bridgework, for we are all aware of them.

Instead of enumerating the possibilities of what may happen to cause the difficulties in the various phases of construction, let us look into the causes. Copper-tube compound impressions are made to make the metal dies. Upon these dies, the gold copings are constructed. Who can say these copings will fit accurately? Then follows the plaster impression in which to seat the copings and dies to create the master cast.

The question arises as to the accuracy of the seating of the copings and dies in this impression. The construction of the dummy thimbles, and the soldering of them to the gold copings are subject to possible discrepancies. Adding error to error, there follows the duplication for making the individual dies on which the unit-built porcelain jacket crowns will be constructed. A method most commonly employed involves the making of copper-tube plaster impressions of each unit, which are packed with amalgam to form the dies. Following this, an over-all impression of the master cast with the gold framework in place is necessary to furnish a seat for these individual duplicate dies; and, finally, the individual jacket crowns are fabricated. The introduction, perpetuation and magnification of error through each successive step in this procedure should be most evident.

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ADVANTAGES OF HYDROCOLLOID IN THE TECHNIQUE

By the use of hydrocolloid, it is possible to fabricate a unitized porcelain bridge through all its intricate and complicated phases with a minimum of error. The initial impression produces a master cast of the prepared teeth in relation to each other and to the adjacent teeth. Upon this cast, the metal framework is made. Hydrocolloid is used to duplicate the cast and produce the dies for each unit. In this procedure, the element of error and guesswork becomes negligible because many of the steps are eliminated, and because highly accurate materials are used throughout.

The technique to be described will show how it is possible to fabricate a unit-built porcelain bridge from start to finish with but two impressions: the initial impression of the prepared teeth in the patient's mouth, and the second impression of the master cast with the gold framework in place. Thus, through the use and mastery of hydrocolloid, it is possible to eliminate many steps in procedure, and to reduce numerous possible sources of error (Fig. 1).

With hydrocolloid, the work must be done on a stone die, and this is the factor which probably creates the greatest mental block to the use of this technique. No doubt special care is required, but, by the same token, it is certain that with a little experience in individual jacket crown construction on stone dies unit-built bridgework on the all-stone dies will become simple. The most important thing is the development of confidence in the ability of the stone die to withstand the fitting of the copings and framework, and later the swedging of the platinum matrices on the duplicate dies. The accurate end results will more than compensate for the investment of such confidence.

The question arises as to whether the laboratory ceramists will be willing to work on stone dies. This problem has been given rather careful consideration, since cooperation between the dentists and the laboratory technician is necessary. The entire procedure has been discussed at length with one of the largest ceramic laboratories in the East. The reaction has been one of avid interest and excitement, as well as willingness and desire to work on stone dies. It has been proved to the satisfaction of the ceramic technician that unit-built porcelain bridgework can be constructed upon the stone dies, and that these dies possess the working strength essential to the procedure. As a matter of fact, they now look upon this method of making unit-built bridges as being just slightly more difficult than making individual porcelain jacket crowns on stone dies.

Again, from the laboratory technicians' point of view, the elimination of so many steps in the procedure is important. They are as aware of this fact as they are of the properties of hydrocolloid in making possible the production of highly accurate casts. The extra care taken in handling the stone dies is completely compensated for by the more accurately fitting restorations with fewer remakes. It is a small wonder, then, that a strong willingness and desire exists for the use of hydrocolloid for this purpose. With but a moderate amount of training,

laboratory technicians can be taught the principles involved, and within a brief period of time they can develop the same degree of proficiency they now possess in handling the amalgam or plated die.

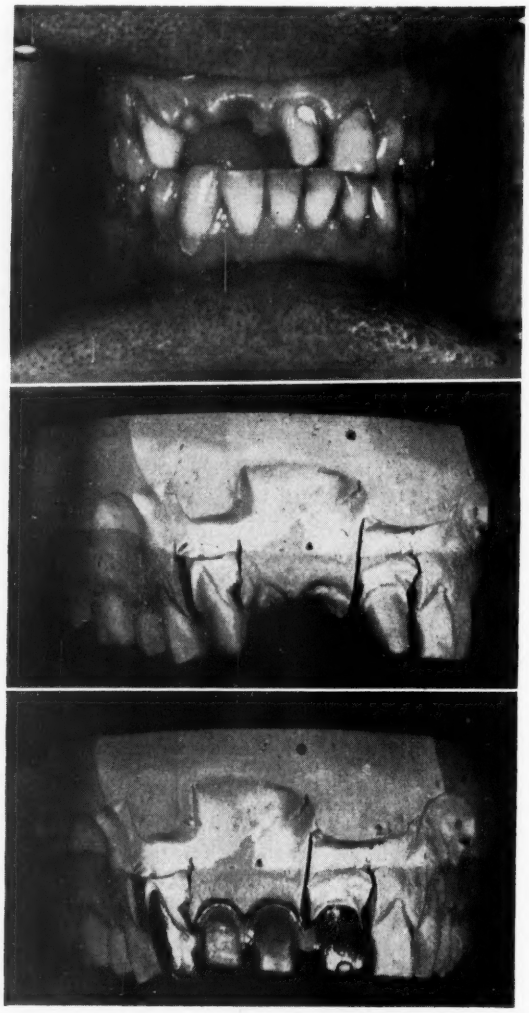

Fig. 1.—*A*, Completed preparations for a unit-built porcelain bridge. *B*, The master cast with the dies cut and trimmed ready for waxing. *C*, The completed gold framework on the cast ready for duplication.

THE TECHNIQUE

Chair Procedure.—A good hydrocolloid, alginate or rubber-base impression of the span which is to receive the bridge is made before the preparations are made. An acrylic resin restoration is prefabricated in this impression to serve as the temporary replacement after the teeth are prepared. The procedures for making these temporary restorations have been described elsewhere, and will not be described

here. The temporary restoration is a vitally necessary adjunct to the entire procedure, for it will maintain the abutment teeth in their relative positions, and provide self-assurance for the patient by maintaining his appearance.

The technique for making the stone dies and cast is exactly the same as that previously described for individual (or multiple) jacket crown preparations,[1] with one exception. Prior to making the hydrocolloid impression, that part of the tray which corresponds to the edentulous area is lined with wax or compound. This is necessary in order to reduce the bulk of the hydrocolloid. Where the hydrocolloid is more than one-quarter of an inch thick, it will not adapt to the tissue perfectly. A space will exist under the unit-built framework if this part of the impression is not perfectly accurate.

The procedure for retraction of the gingival tissues and impression making is essentially the same as that explained in detail for individual or multiple jacket constructions.

Laboratory Procedure.—After the casts have been separated, and the dies have been cut and properly trimmed, the thimbles are waxed on the dies of abutment teeth. The dummy thimble (or thimbles) are waxed where indicated, and joined to the free end next to each of the abutment wax-ups. For example: If the replacement is to be a cuspid-to-cuspid span, the right lateral and central incisors are waxed as one continuous unit. The same is done with the left lateral and central incisors. Each of these is then joined to the corresponding cuspid, and the junction between the central incisors is left free. The two sections are carefully removed from the cast to prepare them for investing.

While we make many one-piece castings, experience has shown that the framework wax-up for the unit-built procelain bridge is too delicate a structure to be removed in one piece without danger of warpage. Therefore, we cast it in two sections, and then join the free ends by making a direct index in the patient's mouth.

Investing the Waxed-up Framework.—We invest the wax-ups for gold coping thimbles in the same manner as we do full coverage patterns when we are working with dies made from hydrocolloid impressions. We use the double investment technique.

1. The two sections are invested in straight Cristobalite, using enough investment to cover the wax pattern completely (after it has been sprued). When this investment is completely set, the investing is completed with straight Cristobalite. Many times the standard inlay rings are found to be too short to accommodate the patterns. Therefore, it is wise to have longer rings on hand before becoming involved in a laboratory procedure such as this.

2. After casting, the two segments of framework are cleaned thoroughly, tried in the patient's mouth, and a direct index is made to relate them for soldering.

Duplicating the Cast with Framework in Place.—

1. The gold framework is now trimmed and finished, making certain that all surfaces are smooth, free of undercut, and that all shoulders are sharp and well defined.

2. Either of the following methods may now be used to produce the duplicate cast and dies:

A. The framework is carefully seated on the master cast, and the lingual undercuts, where the gold tapers gingivally below the shoulders of the copings and the dummy thimbles, are blocked out. The cast is well moistened by being immersed in a water-bath (115°-120°F.) for several minutes, and a hydrocolloid impression is made in a water-cooled tray. To avoid trapping air in this procedure, hydrocolloid is painted or injected directly around each unit and the edentulous area before the water-cooled tray with the firmer, tempered hydrocolloid is placed over the cast. The procedure is the same as is followed in the mouth. By following this procedure, a sharp, well-defined impression for cast duplication will be obtained (Fig. 2). Two such impressions are necessary, since two completed casts are required. One is cut and trimmed and the other left intact.

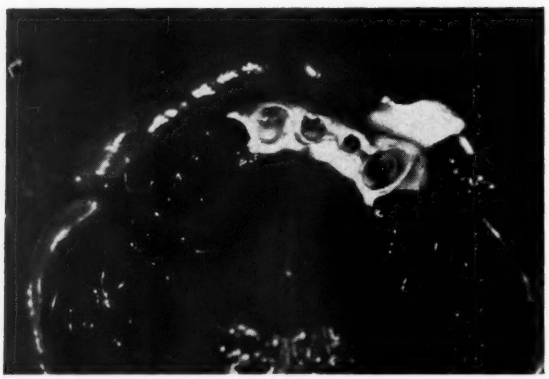

Fig. 2.—The hydrocolloid impression from which the cast and duplicate dies are made.

B. The framework may be cemented in the patient's mouth, and, from this point on, the entire case may be treated as a repair. This procedure, however, creates the need for a set of temporary jacket crowns to be worn over the gold framework. Upon completion of the cementation, carefully and thoroughly cleanse the entire area. Retract only the gingival tissue on the labial side of each abutment tooth. It is not necessary to retract tissue over the dummy thimbles, nor is it necessary to retract tissue on the lingual side, since a gold collar exists about each unit. In the patient's mouth it is not necessary to block out the lingual undercut areas. Proceed now to make the impression in the manner described for multiple preparations. Make two impressions, so that one may be cut for individual dies and the other may be left uncut for the final adjustment of contact points.

3. The hydrocolloid is chilled for five minutes by running water through the tray at a drip rate. This is done to minimize the contraction of the hydrocolloid. The impression is removed from the cast by exerting a firm, rapid force in line with the long axes of the copings and thimbles. If the gold framework should happen to come off in the impression, it is carefully removed to avoid damage to the hydrocolloid impression.

Preparation of the Impression for Pouring.—

1. The same method of dowel placement as that used for porcelain jacket crowns is used to line up the dowels so they are parallel to each other. It is important that the impression is kept moist while the dowels are being placed.

Pouring the Impression.—

1. Care is required in the pouring of the cast because the dummy thimbles are sometimes thin or narrow. The impression is immersed in a 2 per cent solution of potassium sulfate. The stone is mixed to a heavy cream-like consistency, and then the excess moisture is blotted from the stone on a clean towel. The

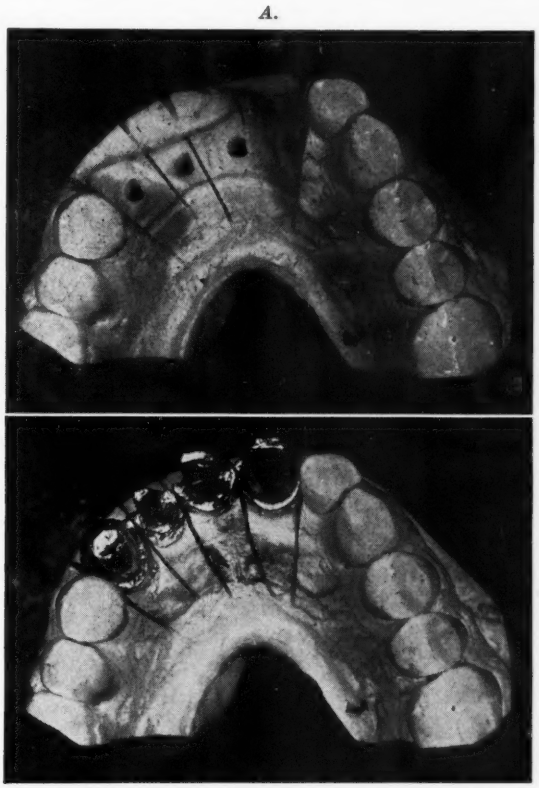

Fig. 3.—*A*, The cast for the unit-built porcelain bridge with the dies removed. Note the definite seat for each die. *B*, The duplicate cast with the platinum matrices swedged and burnished on the dies.

impression is removed from the potassium sulfate solution, and subjected to several blasts of air. The stone is vibrated into the critical areas of the impression, adding very small amounts at a time on the tip of a blunt-end instrument. The stone should flow completely before additional amounts are added. This procedure is repeated until the desired level of stone has been poured into the impression.

2. The procedure for the second pour to form the base of the cast is the same as that used for porcelain jacket crowns.[1]

Creating the Individual Dies.—

1. The under surface of the completed cast is trimmed until the end of each brass dowel is visible. The relationship of each dowel to its corresponding stone stump is studied, and with a pencil the axis of each is outlined on the cast. This will aid in locating the positions of the cuts. The cast is cut with a fine gold saw so that the individual dies may be separated from the cast.

Fig. 4.—*A*, A cast and die made for the repair of a porcelain unit. Note the detail. *B*, The labial surface of the stone die for the repair. *C*, The proximal surface of the repair unit.

There should be no concern about creating too wide a space between the dummy thimbles of stone when the cuts are made to separate the dies, because this space must be wide enough to accommodate the necessary thicknesses of the aprons of the platinum matrices. The cuts are started at the crest of the interproximal apex of each unit. Thus, the individual dies are produced with accurate seats in a cast, and the important die-to-die relationship is correctly maintained on the cast.

2. Platinum matrices are adapted, swedged and burnished, and the individual porcelain jacket crowns are constructed for the unit-built gold framework (Fig. 3). The final adjustments for contact points are done on the uncut duplicate cast.

REPAIRS

Breakage of porcelain bridges is a constant hazard. The use of hydrocolloid makes the repair of broken unit-built porcelain bridges easy. It is simple to produce an accurate duplication of the underlying framework of a broken jacket unit. The technique for a repair is exactly the same as for an individual porcelain jacket. Retraction of the gingival tissue is necessary only when one of the abutment teeth is involved, and then only the labial tissue must be retracted.

When repairs of units are attempted by other impression techniques, many problems and difficulties are encountered. Often the replacement is a very poor substitute for the previous restoration. The hydrocolloid procedure develops a sharp, well-defined, and accurate individual die, and a cast with the adjacent teeth (jackets) in their correct relationship. A repair made by the hydrocolloid technique will fit well and will have the proper contours for esthetics and accuracy in contact points, and, because of the accuracy of fit, will have resistance to breakage (Fig. 4).

SUMMARY

A technique for making unit-built porcelain bridges has been described. The use of hydrocolloid in this technique for the construction of porcelain bridges makes it possible to attain consistent accuracy, which has been impossible by other methods. Many steps required in other techniques and many possible sources of error are eliminated.

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A STUDY OF THE ACCURACY OF HYDROCOLLOID IMPRESSIONS

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THE HYDROCOLLOID or Sears' impression technique has contributed considerably to the accuracy of crown and bridge practice. It is undoubtedly an important step in the progress of technical dentistry.

Much research has been completed in this field, and remarkable contributions have been made. For the most part, however, the quantitative studies have been concerned with the materials themselves, and few accurate measurements have been made of the actual impressions. James[1] has studied the effect of various variables in their influence on the fit of the gold casting on a stone die constructed from hydrocolloid impressions with various materials. Although this work is outstanding in its contribution from a practical standpoint, no quantitative measurements were made.

In this research, the accuracy of an impression of a model prepared for a one-tooth bridge has been studied quantitatively.

DESCRIPTION OF THE MODEL

A model was constructed to simulate the conditions present in the human mouth for the construction of a one-tooth bridge. The model is shown in Fig. 1 as viewed from above. A side view is shown in Fig. 2, with a cast gold bridge in place.

The oversize abutment teeth were constructed of porcelain. The mesiodistal diameter of the teeth was approximately 16 mm., whereas the buccolingual diameter was 17 mm. The height of the teeth was approximately 14 mm.

Typical mesio-occlusodistal cavities were prepared in the teeth. Platinum markers were then fused into the four gingival and two occlusal bases of the prepared cavities as shown in Fig. 1. Reference marks were inscribed on the markers, and designated as *A, B, C, D, E,* and *F* as indicated in Fig. 1.

The base in which the teeth were inserted was constructed of marble. A narrow collar of self-curing acrylic resin was placed around the base of the abutment teeth to simulate the position of the gingival tissues (Fig. 2).

The distances between the markers were measured with the model at a temperature of 37° C. The values for the distances shown in Table I are the average of ten trials. The maximum standard deviation was ±5 microns.

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†Colonel, USAF (DC) (Deceased). Summary of a thesis presented in partial fulfillment of the requirements for the degree of Master of Science in Dentistry, Northwestern University, 1952.

TABLE I. DISTANCES BETWEEN THE MARKERS ON THE MODEL (37° C.)

BETWEEN MARKERS	DISTANCE (MM.)
AB	6.098
BC	6.568
CD	17.467
DE	6.535
EF	6.103

MATERIALS STUDIED

Three reversible and two irreversible materials were studied as to the accuracy of the impressions obtained, as well as a combination of an irreversible with a reversible material. The trade names of the products used with their code numbers are listed in Table II. It is not the purpose of this research to compare one material with another. In fact, as subsequently shown, any differences in accuracy between the various materials were within the limits of the experimental error.

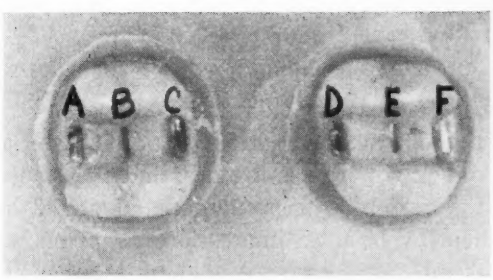

Fig. 1.

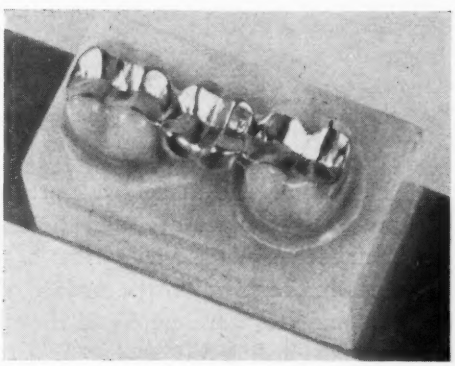

Fig. 2.

Fig. 1.—Occlusal view of the oversize model. The letters represent the designations given to the platinum markers as employed in the tables.
Fig. 2.—A side view of the model with a cast gold bridge in position.

All materials were purchased on the open market through the regular commercial channels.

TABLE II. MATERIALS INVESTIGATED

CODE NO.	TRADE NAME	MANUFACTURER
R-1	Dentocoll	The L. D. Caulk Co.
R-2	Coe-Loid 66	Coe Laboratories, Inc.
R-3	Deelastic	Handy and Harmon
I-4	D-P Impression Cream	Dental Perfection Co.
I-5	Zelex	The L. D. Caulk Co.

PROCEDURE

All of the materials were manipulated as nearly as possible according to the directions of the manufacturer.

The Thompson Conditioner was used with the reversible materials. The material was liquefied by an immersion in boiling water for 10 minutes, and then it was stored for at least 10 minutes at 67° C. (150° F.). The specially constructed perforated tray (Fig. 3) was filled with the sol and conditioned for 4 minutes at 46° C. (115° F.).

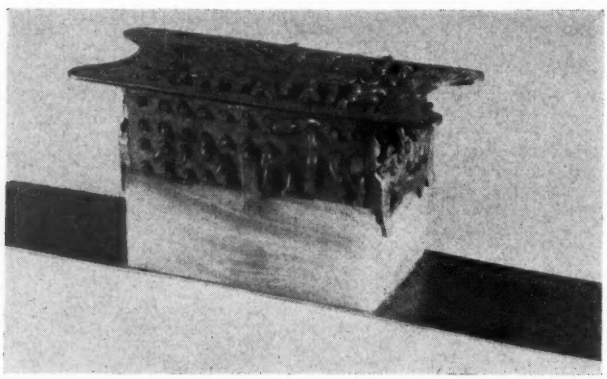

Fig. 3.—The filled impression tray in place on the mod l.

Meanwhile the model was previously stored in water at 37° C. (99° F.). Its surface was wiped dry, and the impression was made at 37° C. The material was extruded into the cavity from a syringe in the usual manner, and the loaded tray was impressed onto the surface of the model. The precautions advocated by Phillips and Ito[2] were employed throughout. The filled impression tray is shown on the model in Fig. 3.

The model with the impression in place was then stored at 37° C. in 100 per cent humidity for 20 minutes for gelation to take place. This departure from the usual clinical procedure was thought justified on the basis that less stress would be incurred in the impression, and as a consequence more uniform results would be obtained.

A similar procedure was employed with the irreversible materials, except that no temperature conditioning of the material was attempted, and the sol was introduced into the prepared cavities with a brush instead of a syringe. The directions of the manufacturer were followed, except that 6 c.c. more water was used than specified, and ice water was employed instead of water at a temperature of 21° C. (70° F.) as is usually advocated. These exceptions to the directions were made in order to delay the gelation time of the materials.

After the impression was obtained, it was allowed to remain on the model at 37° C. in an atmosphere of 100 per cent relative humidity for 3 minutes after its gelation.

In one instance, a combination technique was employed. The prepared cavities were filled with material R-3 with the use of the syringe in the usual manner. The impression tray was then filled with material I-4 and placed in position as usual.

After the specified treatment, the impressions were removed and placed under a measuring microscope, and the distances between the impressions of the gauge marks were carefully measured at room temperature. Three series of readings across the entire impression were made successively at 3.5 minute intervals. Five impressions were obtained with each material and the combination of materials. The differences between the distances observed on the impressions and those determined on the model were expressed as a percentage of the latter. The averages obtained are shown in Table III. A plus sign indicates that the dimension on the impression was larger than that of the model, and a minus sign indicates that the distance was smaller.

TABLE III. PERCENTAGE DIFFERENCES BETWEEN MODEL AND IMPRESSION MEASUREMENTS

MATERIAL	READING NO.	DISTANCES				
		AB (%)	BC (%)	CD (%)	DE (%)	EF (%)
R–1	1	+0.95	+1.49	−1.35	+3.05	−0.13
	2	+1.62	+1.19	−1.60	+3.79	+0.33
	3	+2.05	+1.86	−1.98	+4.34	+0.46
R–2	1	+0.31	+0.53	−0.69	+1.97	−0.39
	2	+1.00	+0.76	−0.92	+2.31	−0.08
	3	+1.03	+1.23	−1.09	+2.69	+0.18
R–3	1	+0.18	+0.75	−0.80	+2.08	−0.10
	2	+0.98	+1.28	−1.19	+2.45	−0.33
	3	+1.49	+1.16	−1.29	+2.69	−0.39
I–4	1	−0.21	−0.35	−0.41	+1.29	−0.16
	2	−0.05	−0.43	−0.50	+1.67	−0.08
	3	−0.03	−0.24	−0.62	+1.93	+0.29
I–5	1	+0.05	+0.58	−0.68	+1.39	−0.18
	2	+0.36	+0.87	−0.05	+2.00	−0.18
	3	+0.99	+1.25	−1.02	+2.51	−0.05
R–3 and I–4	1	0.00	+0.46	−0.40	+1.38	0.00
	2	+0.39	+0.62	−0.48	+1.41	−0.25
	3	+0.67	+0.26	−0.46	+1.81	−0.52

DISCUSSION OF RESULTS

A statistical analysis (analysis of variance) of the data in Table III showed that there is no significant difference between the different materials so far as their accuracy was concerned. Such a finding indicates that the irreversible materials produce as accurate impressions as do the reversible materials under the conditions of the experiment.

The differences in successive measurements with the same material were slightly significant. The general tendency is that the error increases with elapsed time. However, if the stone cast is poured within 10 minutes from the time that the impression is removed, no serious error should be expected.

At first thought, some of the percentage errors are quite large. They are actually not so great, however, in terms of the actual dimensions involved in a practical case. For example, an error of 2 per cent in the distance *BC* on a practical case would be approximately 0.03 mm. With the exception of the errors found in the distance *DE* (Table III) an error of 2 per cent is comparatively high.

The differences in error found betweeen the various distance measurements are very significant, and they should be discussed at some length.

Since the impression material is rigidly retained in the retentions of the impression tray, the most probable interpretation of the data is that a "plus" error may be due to a *contraction* of the impression material or an *expansion* of the impression space, and that a "minus" error may be the result of an expansion of the impression material, or a contraction of the mold space.

This point can be best illustrated by an examination of an impression as shown in Fig. 4. The relationship in this figure is the same as that in Fig. 1, namely, the distances *AB, BC,* etc., extend from left to right. It can be noted that any contraction between the point *A* and the impression tray should cause the distance *AB* to elongate. According to the table, such an increase occurred in every case with one exception (material I-4).

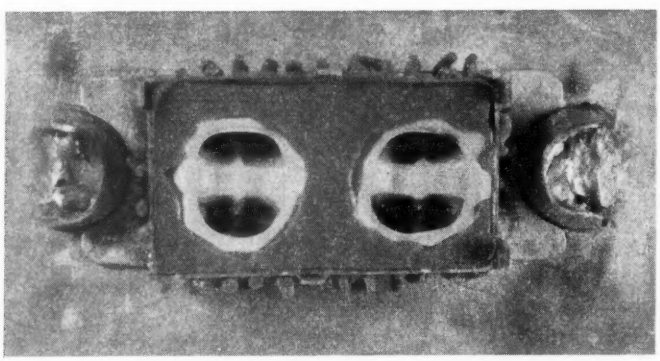

Fig. 4.—An impression made with material R-3. The general relationship is the same as that shown in Fig. 1.

The distance *CD* is considerable in comparison to the other distances, and should exhibit a syneretic contraction, since it is not in proximity to the tray, and, therefore, it is not so restrained as the area around *A*. According to Table III, a contraction occurred in every case along the distance *CD*.

The contraction along *CD* can be expected to cause an increase in the dimensions *BC* and *DE*, due to a stretching effect. Such a change occurred except in the case of I-4, dimension *BC*.

The area F is closer to the tray than is the analogous area A, and as a result the dimension EF is not as greatly nor as consistently changed as the distance AB. However, the lack of material between the area F and the tray may have introduced stresses to the extent that the error in the distance DE was increased over that found with the other distances. Such a hypothesis indicates that sufficient impression material should always be present between the impressed surfaces and the tray, to act as a cushion during the removal of the impression. Another reason, however, for the seemingly large error incurred along the distance DE might be due to the larger undercut in this area as compared to the other contours.

Certainly, the data indicate that the hydrocolloid impressions become stressed upon removal over undercuts. It is doubtful, however, that the discrepancies shown are, in general, of practical interest. Although no quantitative data are at hand, judging qualitatively from the accuracy of the finished product in clinical practice, it is probable that the discrepancies involved are less than those incurred in any other types of impression material employed for the same purpose (e.g., plaster) with the possible exception of the rubber impression materials.[3]

In conclusion, the technique involving the use of a reversible impression material for the prepared cavity, with the irreversible impression material in the tray deserves special consideration. The irreversible hydrocolloid material does not unite with the reversible material as it comes into contact. Any union is strictly mechanical. In order to strengthen the mechanical union, Hollenback[4] advocates that the reversible hydrocolloid be injected into the prepared cavity in excess, and then a small, specially formed piece of perforated metal is laid over the hydrocolloid. When the irreversible hydrocolloid is brought into contact, the reversible material is cooled and gelled, and the perforations in the metal unite the two materials firmly together mechanically. As can be noted from Table III, such a technique is quite accurate.

SUMMARY AND CONCLUSIONS

An oversize model was constructed to simulate the conditions in the human mouth for a one-tooth bridge. Impressions in hydrocolloid were obtained of the model, and their dimensions were compared with the similar dimensions of the model. Three reversible hydrocolloid impression materials were studied, and two irreversible materials, as well as an impression involving both types of materials at one time.

According to the results obtained, the following observations can be made:

1. Impressions obtained with the irreversible hydrocolloid impression materials are equal in accuracy to those obtained with the reversible materials.

2. The technique employing an impression of both reversible and irreversible hydrocolloid materials in combination can be employed with an accuracy equal to that of the other techniques.

3. All of the impressions exhibited distortions after removal, but generally the distortions were considered to be small in comparison to the errors inherent in most other impression techniques.

4. A slight distortion occurred during the 10 minutes during which observations were made subsequent to the removal of the impression.

5. The relation of the impressed areas to their position in the tray is important. In general, a large bulk of impression material between an undercut area and the tray is conducive to a greater accuracy in the impression.

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EVALUATION OF VARIOUS METHODS EMPLOYED FOR CONSTRUCTING WORKING DIES FROM HYDROCOLLOID IMPRESSIONS

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THE EVER-INCREASING popularity of reversible hydrocolloid as an impression material in restorative dentistry has stimulated a vast amount of research relative to its basic physical properties and clinical application. One of the remaining controversial problems in the technique, however, is the exact method for fabricating the working cast. Since the success of the hydrocolloid technique is based upon careful attention to all details concerned with its use, the construction of the stone cast plays a vital role. A number of procedures are widely used, and each technique has ardent supporters. It is probably true that no one technique may be universally acceptable to all dentists. Some undoubtedly have tried and found that certain phases of one particular procedure were not successful, for some unknown reason, in their hands. This has led to experimentation and the outgrowth of various approaches for accomplishing the same end result.

As is true with most new procedures in dentistry, the development of these techniques was based upon empirical observations, and nowhere in the literature can be found scientific evidence to support any one particular method. Thus, it was the purpose of this research to evaluate carefully the accuracy of the more common basic techniques which are now employed in the fabrication of the stone cast.

PROCEDURE

All variables, other than those involved in the construction of the working dies, were carefully standardized. A nonperforated unilateral tray was used throughout. Two representative hydrocolloids, Deelastic† and Surgident‡ were employed with the manufacturers' directions carefully followed in regard to boiling, tempering, and storage. Stone casts were constructed from both hydrocolloids for each technique. In order to assure a good surface on the stone, the hydrocolloid impression was placed in 2 per cent potassium sulfate solution for five minutes before the cast was poured.[1] Likewise, two representative stones, Vel-Mix and Duroc, were used for pouring the impressions. The recommended powder-water ratios were followed, and a mechanical vibrator was used to pour all casts. Unless otherwise stated, the

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‡Surgident Ltd., Los Angeles, Calif.

poured impression was stored in a humidor (approximately 100 per cent humidity) for one hour while the stone hardened.[1] Castings were not tried on the casts until the end of twenty-four hours.

All of the common techniques involve the principle of pouring the critical cavity preparations immediately. Thus it would be expected that the accuracy of the individual die of each cavity preparation would be comparable in every technique. Many procedures, however, necessitate the subsequent use of dowel pins, second pours in the same impression, etc., which could produce distortion of the remainder of the impression during this time interval while the stone is hardening in the original preparation. Reversible hydrocolloid is approximately 75 to 85 per cent water,[2] and there are numerous articles emphasizing the physical phenomena of syneresis and imbibition and the resulting distortion when the impression is stored for any period of time.[3, 4, 5] If the remaining portion of the impression, which is not poured immediately, does fluctuate in water content, then distortion might be expected, and would be evidenced in inaccurate contact reproduction. Likewise, if the impression is distorted by insertion of metal strips, improper trimming, etc., inaccuracy at the contact areas would occur. Therefore, the contacts of a series of gold castings were employed as the criteria for evaluation.

The following cavity preparations were made in Ivorine teeth: DO on a mandibular left bicuspid, an MOD on the second bicuspid, capping the cusps, an MOD on the first molar, and an MOD slice preparation on the second molar. Naturally these preparations were arbitrarily selected, and the type of preparation should have no bearing on the results. The teeth were mounted in an acrylic resin base and accurately fitting castings were made for all preparations. Great care was taken to establish ideal contact on all restorations. The castings now served as the controls and were replaced on the stone casts prepared from each technique to check the accuracy, a method originally used by James.[4] A minimum of three casts was prepared for each procedure, and if there proved to be any discrepancy between the three, additional dies were made.

Silhouette photography was employed as the test method for checking the accuracy of the various techniques. The castings were placed back on the stone cast, and a photograph was taken between each contact area, a total of three silhouettes being required for each cast. Care was taken to place the lens parallel to the contact area so that no overlapping would occur. The silhouettes of the three contact areas (bicuspid-bicuspid, bicuspid-molar,molar-molar) on the original cast can be seen in Fig. 1. The same sequence is followed in all photographs. Silhouettes were taken on all casts, and representative ones are shown in this article. Since many of the techniques produced comparable accuracy to the original, the photographs are not included.

There are innumerable techniques utilized for preparing the working cast, and each procedure has many possible variations. The authors have attempted to select the methods which they felt were most popular. It is quite possible that in certain areas other techniques not included in this study are employed routinely. A summary of the various methods which were evaluated follows:

Group I.—The preparations were poured immediately after the removal of the impressions from the potassium sulfate solution. Upon separation, the base of the cast was tapered, and deep serrations were made on the bottom. The base of the cast was lubricated, and it was mounted in plaster; thus the plaster splint acted as a lock for the sectioned dies. The individual dies were then made by sawing with a jeweler's saw, cutting from the base up, and from the top down to within 2 or 3 mm. of the first cut. This area was then fractured and trimmed. Casts were also constructed in which the individual dies were formed by sawing from one direction only (Fig. 2).

Fig. 1.—Silhouettes of the three contact areas with the castings on the original master cast.

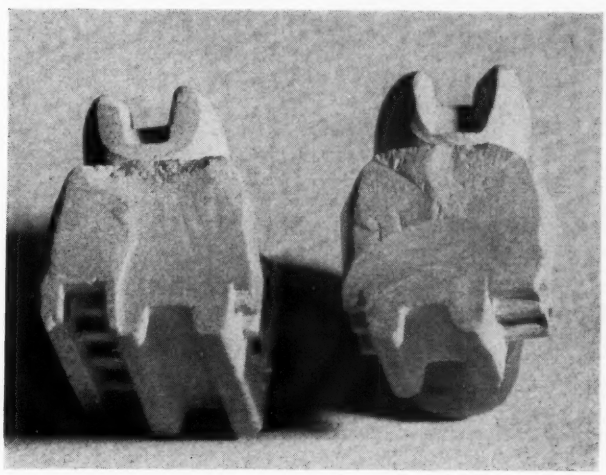

Fig. 2.—Sectioned stone dies, fractured area trimmed.

Group II.—The same procedure as for Group I was used, except that a Key Bar Guide was used for mounting.[6] The serrated surface of the bar was lubricated and placed over the poured impression. Each individual die was then prepared as above.

Group III.—The same as Group II, using the Key Bar, but the sectioned dies were not trimmed at the fractured area (Fig. 3).

Group IV.—Thin metal strips, .001 gauge, were carefully wedged in the impression between the individual cavity preparations.[7] Stability was secured by contouring the strips in such a fashion that they receive support from the buccal and lingual walls of the impression. Only the ends of the matrix metal engaged the hydrocolloid, and the bottom of the metal is short of contacting the hydrocolloid at the mesial floor. Care was exercised to prevent distortion during the insertion of these strips. With the metal strips in place, the preparations were poured up

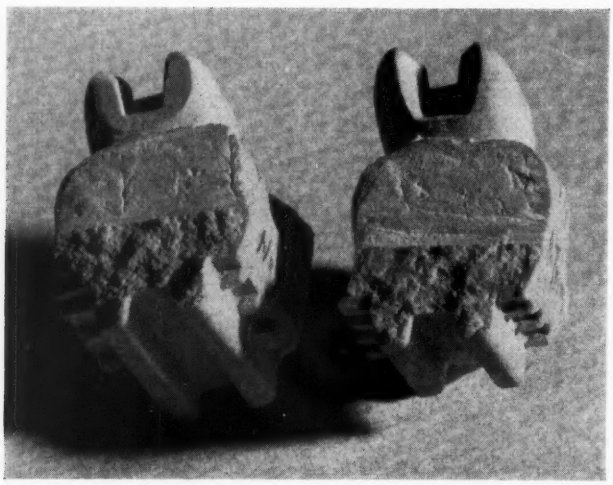

Fig. 3.—Sectioned stone dies showing untrimmed stone. Uneven surfaces prevent the proper repositioning of dies.

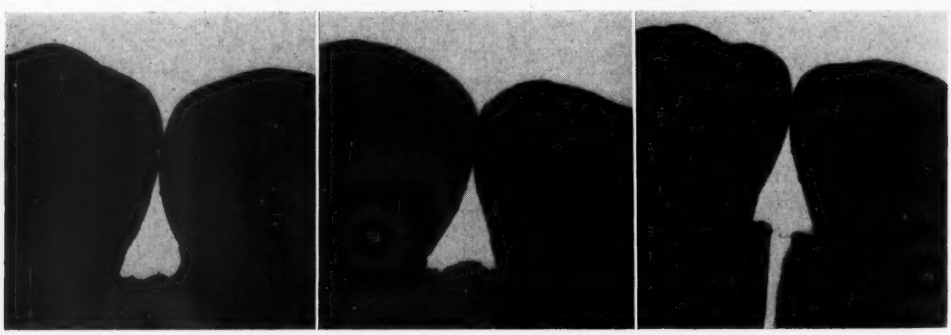

Fig. 4.—Silhouettes of contacts as obtained from sectioned dies. Accuracy is comparable to that of the original. Several of the other techniques, carefully done, produced identical results.

to a level approximately 1 to 2 mm. short of the ends of the metal strips. The serrated area of the Key Bar was lubricated, partially poured, and luted to the poured impression. Upon separation, the sectioning of the dies was facilitated by the metal strips.

Group V.—The same as Group IV, except a heavier, .002 gauge, metal was used. Other dies were poured also, in which the thinner gauge metal was used, but the strips were pushed down into the floor of the preparation.

Group VI.—The individual preparations were poured, and dowel pins were then inserted into each die, freehand.[7] The dowel pins were placed, as nearly as possible, parallel to the long axis of the tooth and with each other. At the end of a half hour, the cast was removed from the impression, the ends of the dowel pins and top of the initial pour were lubricated, and the remainder of the cast was poured.

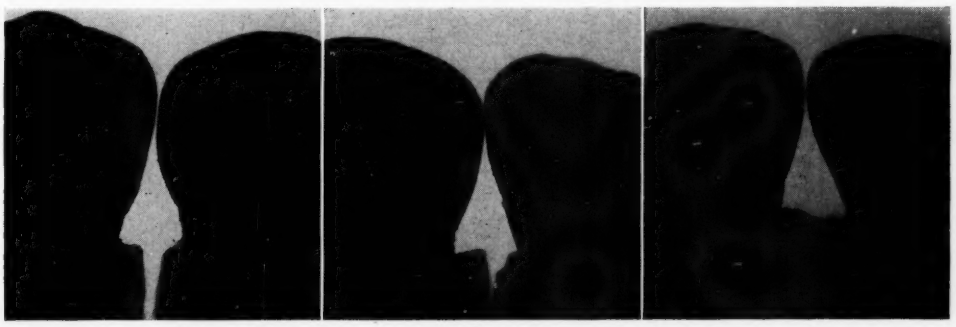

Fig. 5.—Inaccuracy, as shown by open contacts, due to not trimming the fractured areas of the die.

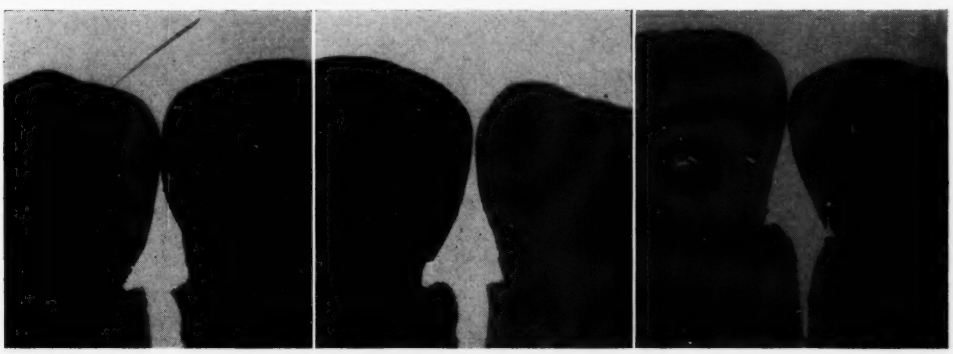

Fig. 6.—The use of heavy metal strips or pushing thin strips too far into the hydrocolloid causes distortion.

Group VII.—This series was essentially the same as the previous group except a paralleling instrument* was used for alignment of the dowel pins.[8, 9, 10] The stone was vibrated into all the vital parts of the impression. The poured impression was then returned to the plaster matrix on the parallator and the pins were inserted. The poured impression was maintained in 100 per cent humidity by placing wet gauze packs on the tray adjacent to the impression and encasing the entire tray by a wet towel, covering the instrument and the poured impression during the set of the stone. A different color of stone was used for completing the pour in order to produce a separating line for sawing through the vital part of the cast.

Group VIII.—The same as Group VI, except the poured preparations were placed in a 2 per cent potassium sulfate solution, rather than the humidor, while the stone hardened.

*One instrument supplied through the courtesy of Mr. Harlan Wooster, Jacksonville, Fla., and the other by the J. F. Jelenko Co., Inc., New York, N. Y.

Group IX.—Some operators feel that the use of cotton fibers impregnated into a covering of compound on the tray will help minimize any distortion of the hydrocolloid during removal from the mouth and pouring.[7, 11] A series of dies was run to check the accuracy of this method. The entire inside surface of the tray was covered with a thin layer of Kerr Compound. The compound was softened by ether, and then cotton fibers were placed against this sticky surface. These fibers became enmeshed in the body of the hydrocolloid. The same technique as in Group VI was employed for the construction of the dies.

RESULTS

Analysis of the silhouette photographs showed that several of the techniques produced an accurate final die, if careful adherence was given to the fundamental steps. However, some interesting observations were made concerning the various groups.

The photographs of the contacts of the dies prepared in Group I (Fig. 4) showed the same accuracy as the original (Fig. 1). The use of the Key Bar (Group II) gave identical results. The inaccuracy in Group III, however, is evident in Fig. 5. In this case the poured casts were not trimmed and the fractured parts did not go back in proper apposition, leaving the contacts open. Trimming this area is necessary, regardless of whether dowel pins, metal strips, or a solid cast is used.

Fig. 7.—An individual die showing the fit of the master casting and resulting inaccuracy.

No difference was detected if the cast was cut from the top or from the bottom. The use of a thin metal strip, Group IV, produced results comparable to those in the original. The use of a heavy gauge strip (Fig. 6), however, caused distortion of the impression and improper contact. The discrepancies are evident, particularly in the cervical and occlusal areas. In Fig. 7 can be seen the actual fit of one of the master castings. The casting does not fit the stone cast due to the distortion of the hydrocolloid. Identical results also occurred when the thin metal strips were pushed too far.

The use of dowel pins and paralleling instruments (Groups VI, VII, VIII, IX) all gave accuracy, and since the silhouettes were identical to the control, they are not included.

CONCLUSIONS

Various techniques can be satisfactorily employed in the construction of working dies poured in hydrocolloid impressions. In this study of the contact areas, no discrepancies could be detected in the careful use of split casts, dowel pins, paralleling instruments, and thin metal strips. Plaster matrices and the Key Bar Guide gave comparable results. Inaccuracy was evident whenever the fractured dies were not trimmed, and when the metal strips were too thick or pushed too far into the impression.

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SOME EXPERIMENTS ON THE SURFACE HARDNESS OF DENTAL STONES

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ONE OF THE FEW DISADVANTAGES of the modern hydrocolloid technique for crown and bridge work is that a gypsum die must be employed for the preparation of the wax pattern. Under no circumstances is the surface hardness of any modern gypsum product comparable to that of the metallic materials usually employed for this purpose, such as low-fusing metal, amalgam, copper plating, and so forth. The abrasion resistance of the stone is likely to be so low that unavoidable minute marginal discrepancies may be produced during the carving and the burnishing of the wax pattern.

Until some other die material is found which can be used successfully in impressions obtained with the hydrocolloid materials, the surface hardness of the stone die merits attention.

It was the purpose of this research to investigate (1) the surface hardness of the gypsum die material as it may be affected by the hydrocolloid impression material, and (2) the possibility of increasing the surface hardness of the stone by special processing methods.

The trade names of the commercial products studied are not important to the present research since a new technique is studied which has not been considered heretofore. The products were selected on a basis related both to their popularity and to possible differences in composition. The trade names of the products are listed in Table I, together with their basic ingredient as a matter of record, and not for any purposes of comparison. As can be noted, six reversible (agar) hydrocolloid impression materials were studied, together with four irreversible (alginate) materials.

The die materials studied were all gypsum products, and they were selected as being typical of a particular class of such products. "Duroc," for example, is presumably typical of the new so-called "hard stones." Technically, it is known as a *low consistency stone*. "Coecal" is representative of the stones of the regular or usual consistency type. Clover Leaf Plaster happened to be a model plaster readily available at the time of testing. The low consistency Hydromite was an experimental resin stone furnished by the United States Gypsum Company.

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A soluble resin has been added to this material, presumably to increase its strength. Hydrocal A-11, an alkaline stone, was also furnished by the same company. The last two products are not employed generally in dental procedures.

TABLE I. MATERIALS STUDIED AND BASIC INGREDIENTS

Trade Names	*Basic Ingredients*
Hydrocolloid Impression Materials.—	
Coe-Loid 66	Agar agar
Dentocol	Agar agar
DP Colloid	Agar agar
DP Impression Cream	Soluble alginate
Jeltrate	Soluble alginate
Kerr Hydrocolloid	Agar agar
LS-2*	Soluble alginate
Plasticoll	Agar agar
Surgident	Agar agar
Zelex	Soluble alginate
Die Materials (Gypsum Products).—	
Duroc	Alpha hemihydrate (l.c.†)
Clover Leaf Plaster	Beta hemihydrate
Coecal	Alpha hemihydrate (r.c.‡)
L.C.† Hydromite (experimental)	Alpha hemihydrate (l.c.†)—resin
Hydrocal A-11	Alpha hemihydrate (alkaline)

*No longer marketed.
†Low consistency.
‡Regular consistency.

SURFACE HARDNESS OF STONE SETTING AGAINST A HYDROCOLLOID GEL

The first study was made to determine the possible effect of the hydrocolloid gel on the surface hardness of the stone die.

The impression materials were manipulated according to the directions of the manufacturers. In the case of the reversible materials, a mixing syringe was used during heating in order to assure the best possible results.[1] After the solutions of the various materials had been obtained, they were poured into brass rings, 2.7 cm. in diameter and 1.5 cm. in altitude, and allowed to gel between glass plates* on the top and bottom of the ring. If a hardening solution was employed, the appropriate specimen was immersed immediately after gelation.

The surface of the gel was treated with a hardening solution if such a treatment was specified by the manufacturer; and in addition, with the exception of material DI (Table II), a specimen of each gel was immersed for ten minutes in various solutions as indicated in Table II.

A mixture (W/P ratio = 0.23) of the low consistency stone (Duroc) was then poured into a similar brass ring, placed immediately above the ring containing the hydrocolloid gel. The powder and water were mixed mechanically for 15 seconds under vacuum. Control specimens of the stone were prepared by pouring the stone against a clean glass surface. In all cases, the stone was not separated from the gel or glass for 1 hour after the pouring. All gypsum specimens were conditioned at 50° C. (122° F.) for 72 hours before testing for surface hardness.

*Cellulose sheets used with material DI (Table II).

TABLE II. INFLUENCE OF VARIOUS HYDROCOLLOID IMPRESSION GELS ON THE HARDNESS OF THE STONE SURFACE (DUROC)

HYDROCOLLOID MATERIAL	MFR. DIRECTIONS K.H.N.	K_2SO_4 (2%) K.H.N.	$MnSO_4$ (15%) K.H.N.	$KAl(SO_4)_2$ (2%) K.H.N.	$ZnSO_4$ (2%) K.H.N.
Irreversible.—					
AI	32.4	38.8	27.6	*	39.6
BI	45.9†	*	30.1	40.6	49.0
CI	32.7†	*	28.0‡	30.6	*
DI	33.0§	——	——	——	——
Reversible.—					
ER	28.9	30.2	30.2	24.7	24.1
FR	30.0	32.1	37.0	32.1	29.6
GR	29.1	30.0	30.1	33.5	30.5
HR	32.4	23.4	33.2	27.5	37.3
JR	32.0	29.2	31.4	26.7	27.6
KR	31.0	27.8	31.8	43.1	35.2

Control: Stone allowed to set against a glass surface, K.H.N. = 51.8.
*Surface chalky—indentation not sharp.
†Hardener supplies by the manufacturer.
‡Results very erratic.
§Gel allowed to form against cellulose sheet instead of glass.

The gypsum specimens were tested for hardness with a Knoop indenter as employed on the Wilson Tukon Tester under loads of 500 Gm. or 1000 Gm. This test was employed because it was thought that only a thin shell or layer of the stone should be tested. Other hardness testers available at the time produced too great a penetration of the surface during the indentation.

At least two trials were made in each case. Five Knoop impressions were made on the surface of each stone specimen. The variation (s.d.) in hardness measurements obtained during the two trials was less than 3 hardness numbers.

The results of this series of tests are presented in Table II, column 2. The hardness numbers represent the hardness of the stone surfaces when the hydrocolloid gel was treated according to the directions of the manufacturer. As can be noted, in only two cases (materials BI and CI) was treatment of the gel surface with a hardening solution advised by the manufacturer. When the stone was allowed to set against a glass surface, a Knoop hardness number of 51.8 was obtained. It is evident that only in the case of material BI, for which a hardening solution was prescribed by the manufacturer, did the surface hardness of the stone which set against the hydrocolloid gel even approach that of the control specimens which set against a glass surface. In all of the other instances, the hardness of the stone was definitely reduced to approximately the same magnitude (K.H.N.29-33).

In all probability, the lowered hardness of the stone surface is due to the retarding action of the gel at the interface between the gel and the stone. The immersion of the gel in a hardening solution before the stone die is constructed very likely neutralizes, to some extent, the retarding action of the gel, since the hardening solution is also an accelerator for the setting of gypsum products.[5] It

follows, therefore, that the retarding effect of any of the gels might be overcome if they were treated with the proper stone-hardening solution. This idea was the basis for further experimentation with various hardening solutions as indicated in Table II, columns 3-6, inclusive. It has been frequently recommended[1,3] that the hydrocolloid impression be immersed in a 2 per cent solution of potassium sulfate in order to provide a smooth surface on the stone die. The results obtained when this hardening solution was employed are shown in Table II, column 3. Only in the case of material AI was the stone surface improved. In the case of materials BI and CI, the stone surfaces were so soft that the Knoop impression could not be measured. The surface hardness of materials HR and KR was evidently reduced by treatment of the gel in this solution.

Next, a solution of manganous sulfate (15 per cent) was used as a hardening agent. The stone surface obtained from the gel FR was improved, but no other important increases in stone hardness were noted. Potash alum is often incorporated in reversible hydrocolloid impression materials as a plaster-hardening agent. An important improvement was effected with this hardening agent, in the case of the stone surface which set in contact with material KR (column 5, Table II). Otherwise, no improvement of interest was noted.

Zinc sulfate is often employed as a hardening agent with alginate impression materials (e.g., hardening solution supplied by the manufacturer for use with material BI). The results shown in the last column of Table II indicate that a 2 per cent solution of zinc sulfate was quite effective in improving the surfaces of stone specimens obtained from materials AI, BI, HR, and KR.

It is evident from the above discussion that the hardness of a stone surface can be improved by the use of a proper hardening agent applied to the surface of the hydrocolloid gel. Probably no single hardening agent can be used for all hydrocolloid materials. The composition, osmotic pressure, and similar factors in the gel are undoubtedly different for different materials. Consequently, the composition and concentration of the solution will need to be specified for each material. Such a specification should be developed by the manufacturer and supplied with the material.

EFFECT OF THE TYPE OF DIE MATERIAL

It is, of course, possible that a type of gypsum die material may be found which will be less affected by the gel than are the present materials. In order to test this point, the surface hardness of all of the gypsum products listed in Table I was tested after they had set against the gels formed from materials AI and HR. No hardening solutions were used. As before, the hardness values for the control specimens were obtained with stone surfaces which had set against glass. The results are shown in Table III.

A comparison of columns 4 and 5 with column 3 in Table III indicates that the surface hardnesses of the various stones were all reduced by the gels during setting, with the exception of the Coecal and the Clover Leaf Model Plaster, and with the possible exception of the l.c. Hydromite when it set in contact with gel HR. Regular consistency stones (e.g., Coecal) are often quite sensitive to surface

TABLE III. EFFECT OF HYDROCOLLOID GEL ON SURFACE HARDNESS OF VARIOUS TYPES OF GYPSUM MATERIALS

MATERIAL	W/P	CONTROL	HYDROCOLLOID	
		K.H.N.	AI K.H.N.	HR K.H.N.
Duroc	0.23	51.8	32.4	32.4
Coecal	0.28	24.6	24.1	23.9
Hydromite	0.18	35.2	29.5	34.9
Hydrocal A-11	0.28	60.4	38.6	29.3
Clover Leaf Plaster	0.70	7.0	8.1	8.1

disturbances in contact with hydrocolloid gels, but such an effect was not evident in the present case. Although model plaster is probably too soft to be used as a die material, it has been observed repeatedly in this laboratory that the surface of the set plaster is seldom affected by a hydrocolloid gel, regardless of its composition (within the range of dental use). The reason for this difference between plaster and other gypsum products is not clear.

EFFECT OF CHEMICAL ADDITIONS TO THE STONE

Another possible solution to the problem might be to add a modifier to the stone, which might counteract the retarding action of the hydrocolloid. Since zinc sulfate and potash alum appeared to be the most effective hardening agents, 2 per cent solutions of each were used for the mixing of the stone (Duroc). A solution of sodium silicofluoride was also used, since it is known to be the plaster-hardening agent in at least one of the commercial alginate impression materials.

TABLE IV. EFFECT ON SURFACE HARDNESS OF CHEMICAL ADDITIONS TO THE STONE (DUROC, W/P RATIO = 0.23)

MIXING SOLUTION	CONCENTRATION (%)	K.H.N.*
Water	100	51.8
Zinc sulfate	2†	51.9
Potash alum	2	53.4
Sodium silicofluoride	Saturated	65.4

*After setting against a glass surface.
†Contained in addition 0.1 per cent of potassium sulfate in order to regulate the setting time.

The Knoop hardness numbers of the specimens obtained are shown in Table IV. No effect of the different solutions was noted in the surface hardness, with the exception of the stone prepared with the sodium silicofluoride.

Unfortunately, when the stone specimens were allowed to set against the gel obtained wtih hydrocolloid material ER, all of the surfaces were reduced to a Knoop hardness number of approximately 31, regardless of the solution employed.

SURFACE TREATMENT OF THE STONE DIE

A possible third method for the hardening of the surface of the stone might be to treat its surface after it has set. Various methods have been suggested for such a treatment, but to date none of them have proved valid under test. For

example, Peyton and his co-workers[4] have shown that an immersion of the die either in water or in oil after it has set reduces hardness, crushing strength, and abrasive resistance of the stone.

Buchanan and Worner[5] have reported that the surface hardness (K.H.N.) of a plaster cast after immersion in a solution of borax can be increased as much as 140 per cent. This method of surface hardening was studied in the present research in connection with specimens of die stone (Duroc) and plaster (Clover Leaf Model), the surface of which had been allowed to set against a glass plate.

The specimens were treated as indicated in Table V. After each treatment, they were dried as previously described. As can be noted, the surface hardness of the plaster was definitely increased by the treatment, but the hardness gained did not approach that of the stone, even after the latter set in contact with a hydrocolloid gel (Table II). For some reason, the surface of the stone was not appreciably affected by the treatment.

TABLE V. SURFACE HARDENING TREATMENTS OF THE STONE DIE AFTER SETTING

TREATMENT	DUROC K.H.N.	CLOVER LEAF MODEL PLASTER K.H.N.
Control (usual treatment)	51.8	6.0
In Saturated Borax Solution.—		
Immersed 1 hr.	56.0	——
Immersed 3 hrs.	46.6	20.3
Boiled 15 min.	49.6	13.0
Immersed in Stearic Acid.—		
(80° C.) for 2 minutes	51.5	——

A dental laboratory technician claimed that the surface of a dental stone die can be hardened by immersing the die in a stearic acid bath at 80° C. (176° F.) for 2 minutes. As can be noted from Table V, such a treatment was not found by us to be effective.

It might be stated in defense of surface treatments of stone dies with oils and greases that perhaps the surface may be rendered so smooth by the treatment that the wax carver is not so likely to cut the stone as it glides or skids over the surface. Such a phenomenon may, however, inspire a false security in the operator by virtue of an appearance of a surface hardness which does not exist.

SUMMARY

One of the disadvantages of the Sears, hydrocolloid indirect technique is the use of a stone die in the preparation of the wax pattern. The stone die is not sufficiently hard to resist the abrasion of the carving instrument during the carving of a wax pattern. Experiments have been performed to determine the effect of the hydrocolloid gel on the hardness of the stone surface, and to investigate methods to increase the surface hardness of the stone by various means.

According to the results presented, the following statements can be made:

1. Unless a hydrocolloid impression is previously treated with a hardening solution, the surface hardness of the die stone (as indicated by the Knoop hard-

ness number) is definitely less than that obtained when the stone is allowed to set against a glass surface.

2. Treatment of the hydrocolloid impression, regardless of its composition, with a hardening solution will undoubtedly improve the surface hardness of the stone die. The optimum composition and concentration of the hardening solution, however, may vary from one commercial hydrocolloid material to another, and it should be specified by the manufacturer of the product.

3. When some of the hardening solutions were mixed with the stone instead of water, no increase in surface hardness resulted when the mixtures were allowed to set in contact with one of the hydrocolloid gels.

4. It was noted that the surface hardness of model plaster is not affected by the hydrocolloid gel, but that its hardness is too low for its use as a die material.

5. Soaking the gypsum product in a saturated solution of borax increased the surface hardness of set plaster markedly, but such a treatment did not affect the hardness of the stone.

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A STUDY OF SOME VARIABLES ASSOCIATED WITH COPPERPLATING OF DENTAL IMPRESSIONS

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THE COPPERPLATED, or electroformed, die has become increasingly popular since its introduction to dentistry in 1840.[1] It does offer certain advantages over a stone or amalgam die,[1–5] mainly in the increased hardness and abrasion resistance to wax carving procedures and to the swaging of platinum matrices.

Because of the vast amount of research conducted by various industrial concerns, electrodeposition procedures are well standardized but, unfortunately, the plated die used in dentistry offers certain peculiarities in its construction that are not commonly encountered in industry. The materials are different, the dental die is small, and the plate must be deposited inside the small concavity of the dental impression; therefore, the first layer of the plated copper is most critical and is often difficult to secure. It is this first layer that determines the character of the surface of the finished die and also the degree of accuracy of the reproduction.

A review of the literature discloses that there are several methods used for converting the nonconducting impression material into a conductor. This process is referred to as metallizing. Many have contributed to the development of various techniques.[3, 6–11]

Critical examination of copperplated dies fabricated by different metallizing agents and techniques reveals, in many instances, a certain amount of surface roughness and loss of detail. To date, no one has attempted an evaluation of the surface quality or accuracy of detail resulting from the various metallizing methods. That was the purpose of this investigation, as well as to study certain other variables which have not previously been covered in the research related to the dental electroformed die.

PROCEDURE

The following metallizing materials were studied: Silbryte, Aqua-Dag, oil of bitter almonds and bronzing powder, Silverizer, and the precipitation of a silver film. It is recognized that other techniques are utilized, but these are representative and the most popular.

Since a great portion of this investigation was devoted to the influence of the various metallizing agents upon the surface of the original compound impression,

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it was necessary to make a master die which would resist subsequent marring or scratching during the fabrication of the large number of impressions to be used. A nickel steel die was machined. One end was flat (11 mm. diameter), while the other end had five precision ground serrations (1.5 mm. in depth and 2.1 mm. from ridge to ridge) which presented knifelike edges and were thus comparable to a sharp cavity preparation margin (Fig. 1). Thus, these two dies made possible a microscopic evaluation of the influence of the various techniques on both a flat and a sharp area.

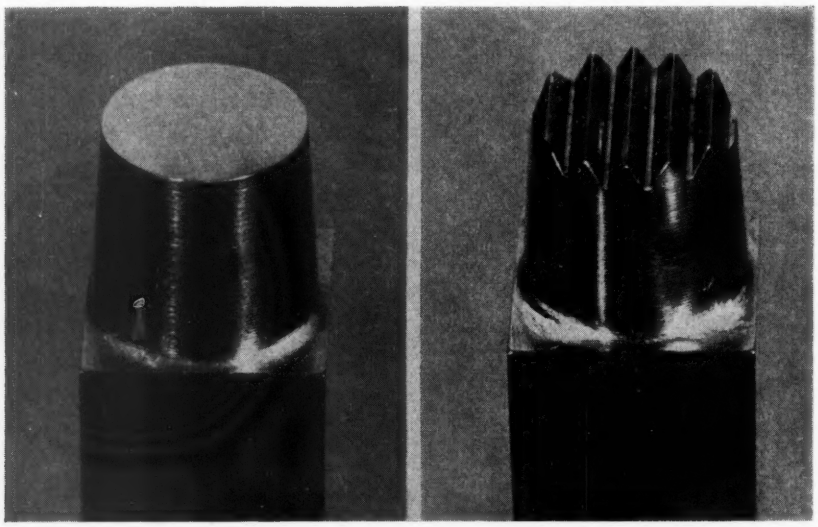

Fig. 1.—The two master steel dies used in this research.

Copper bands were filled with melted tray compound, pressed over the chilled die, and immediately immersed in ice water. All impressions were examined under low-power magnification, and any which showed inaccuracy or surface flaws were discarded.

The metallized impressions were luted with melted wax to Hanau electrodes and then wrapped with cellophane tape to form a protective collar. Unless otherwise stated, this collar extended 2 to 3 mm. past the open end of the impression. If the collar is too long, the throwing power of the solution is inadequate, while a shorter collar results in too rapid a build-up of copper at the open end of the impression.[3, 6, 11-13] Our preliminary work corroborated this.

To remove the entrapped air that tends to cling to the sides, many suggestions are offered in the literature for introducing the metallized impression into the plating bath. In this study, we found that the best method was to dip the impression into ethyl alcohol[5, 11] and, when filled, immerse it with slight agitation into the plating bath. This method is contraindicated when the silver-film method of metallizing is used, since the silver film flakes off when placed in ethyl alcohol. Since the surface tension of the silver film is very low as compared to that in the other methods, however, it is possible merely to introduce the impression into the bath and agitate it back and forth at the surface to remove all air bubbles.

The plating apparatus consisted of a glass battery jar containing 16 L. of an acid sulfate bath of the formula described later in this article.

The electrical circuit consisted of a Mallory rectifier supplying filtered direct current. A milliammeter (0-1,000 Ma. range) was used in measuring the current density, and the current was controlled by means of a small rheostat built into the rectifier. A 3 inch square rolled copper bar was employed as the anode. The cathode-anode distance was established at 3 to 4 inches. This particular distance was selected since it is recommended by various authorities[3, 13] and was found by the authors to produce optimum results on the dental impression.

Impressions were made of both the smooth and serrated ends of the master die. A minimum of 75 impressions was metallized with each of the five methods. Generally, 10 impressions, 2 for each of the five techniques, were plated at one time, at 100 Ma. for a period of 10 hours. The impressions were removed from the bath, washed, rinsed, and blown dry. The electroformed shells were then filled with a mix of stone. The hardened dies were separated and rinsed in chloroform to remove the adhering compound. The dies were examined under three magnifications by both investigators. Photographs of representative surfaces will be used in this article.

The exact method of metallizing with each technique is described as follows.

Aqua-Dag.—A small amount of this substance (approximately 2 mm. in length) was squeezed from the tube and was mixed with a drop or two of water to make a black inklike liquid. It was brushed onto the surface of the impression and the edge of the copper band to insure adequate electrical contact. According to Frankel,[12] the electrical conductivity of this substance is low. An average of 20 minutes was required to attain full coverage of the impression.

Silver Film.—A silver film, approximately two millionths of an inch thick,[14, 15] can be deposited evenly over the surface of the impression by the chemical reduction of an aqueous solution of silver nitrate. Although most formulas for the production of silver films are exacting and rather delicate to use, this procedure works well even with wide variations from the original formula.[3, 6] The formula which was employed throughout this study was altered slightly from the one in the literature. Caution should be exercised in the handling of the silver nitrate solution because it produces black stains on most substances with which it comes in contact.

The impression to be metallized was first lightly painted with the sensitizing solution to ensure coverage and then immersed in this solution for several minutes. The composition of this solution is:

Hydrochloric acid, concentrated	1.5 ml.
Stannous chloride	1.0 Gm.
Distilled water	100.0 ml.

Although the exact mechanism is not known, apparently the stannous chloride tends to wet the surface more easily or actually gives the surface an affinity for the silver ion.[3, 14-16]

The impression was then removed, rinsed *gently* with tap water, and placed in another cup or beaker. A small amount of the reducing agent, sufficient to cover the impression, was poured into this vessel. The composition of this solution is:

Pyrogallic acid, crystals	3.4 Gm.
Citric acid, granular	0.7 Gm.
Distilled water	100.0 ml.

Silver nitrate solution, triple the amount of the reducing agent, was then poured in. This solution is as follows:

Silver nitrate, crystals	4.4 Gm.
Distilled water	100.0 ml.

There are a number of complex intermediate compounds found in the reaction of pyrogallol and silver nitrate, but the net result is the precipitation of a silver film.[17] The solution turned black in color, and after setting for five or ten minutes, it turned to a lighter brown color. The solution was then poured out and tap water used to rinse the metallized impression. Examination of the impression, after drying with a blast of compressed air, showed that a light grayish silver film evenly covered the entire impression. Occasionally there were voids in a small and deep impression. These were covered easily by repeating the process.

Surface tension difficulties are practically nil; therefore, no wetting agent need be used. The dry impression is merely immersed in the plating bath and agitated back and forth a few times to remove any entrapped air bubbles. The copper deposit entirely covers the impression in approximately 30 seconds. The electrical conductivity of this film is obviously high.[12]

Contrary to the apparent complexity of the technique, it is extremely simple to use and does not require particular proficiency on the part of the technician.

The sensitizing solution may be used indefinitely and seems to have unlimited shelf life. However, the reducing and silver nitrate solutions do deteriorate. Storing these two solutions in dark bottles helps stability. The solutions which were used in this work produced excellent results after being stored for several months, even though there was some darkening of the reducer and some silver oxide precipitated in the silver nitrate solution. The solutions are not explosive as are ammoniacal silvering solutions.[18]

Silbryte.—This product, now marketed as Stallite, comes in two bottles, one containing the burnishing metallic powder and the other a liquid. A small sable hair brush was used to apply a thin film of the liquid to the entire surface of the impression, making sure that it was brushed up to the ends of the copper band in order to ensure adequate electrical contact. The best results were obtained when the powder was brushed over the surface just before the liquid completely dried. The excess was then returned to the bottle, and another brush was used to burnish the powder. This burnishing action tended to remove the excess in the sharp corners of the impressions and produced a smooth metallic sheen to the surface. Full coverage was attained in an average time of two to five minutes.

Silverizer.—This procedure involved the use of a coating of a very fine-grained silver powder dispersed in a bottle of thin, volatile liquid. There are other methods

of applying Silverizer; however, this one was chosen since it was the only technique which made use of a one-step, powder-liquid method of metallizing. Since the liquid is very volatile, it is necessary to brush the material rapidly onto the surface of the impression and up to the end of the copper band. Full coverage was effected in a very short time, usually in less than two minutes. The silver powder obviously is a good electrical conductor.

Oil of Bitter Almonds and Bronzing Powder.—The oil should be applied only in a very thin layer as thick layers will cause pitting of the compound surface. It is slow drying and requires at least ten minutes before application of the powder. The specific powder used was Venus No. 108 manufactured by the American Bronzing Powder Corporation, New York. The powder is burnished in the usual manner. The time required to effect full coverage of the impression was somewhat slower than with the other powder-liquid methods. This indicates an electrical conductivity between that of Aqua-Dag and the silver film.

RESULTS

Only a few representative photographs will be used to illustrate the results obtained. All of the powder-liquid methods tended to induce a definite surface roughness, particularly at the outer edge. In Fig. 2 can be seen the surface of a die secured from an impression metallized by means of oil of bitter almonds and bronzing powder.

Best results for all the powder-liquid methods, however, were obtained with Aqua-Dag (Fig. 3). The light and dark areas are caused by the tendency for some of the Aqua-Dag to come off the plated die. This is undesirable in the construction of anterior jacket crowns because the graphite which is unavoidably removed during the fabrication of the crown will contaminate the resin.

The smoothest surface was obtained by the silver-film method (Fig. 4). This superior reproduction of the original surface appears to be attributable to two factors—the extremely small grain size of the precipitated silver, and the advantage of not having to touch the impression with a brush. This film adheres tenaciously to the surface of the copper die after separation from the impression, a common fault with some other techniques.

When the sharp, serrated die was used for studying the accuracy of reproduction, results comparable to those in the previous series were obtained. The surface of the master steel die can be seen in Fig. 5, and a typical compound impression made of this surface is shown in Fig. 6. The impression is, of course, a negative of the steel die, and during metallization it is necessary to burnish into the depths of the sharp serrations—comparable to the grooves and other details of a prepared tooth impression.

Most of the powder-liquid methods produced good detail in certain areas, but in others there was a break in the continuity of the knifelike edges, due to the inability to burnish away all excess powder effectively. Likewise, the side surfaces of the serrations are somewhat rough due to the large powder size. A typical surface can be seen in Fig. 7. As before, the best results with the powder-liquid methods

Fig. 2.

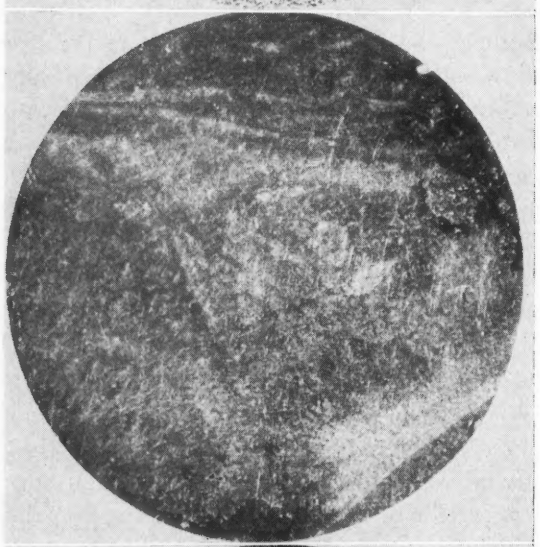

Fig. 3.

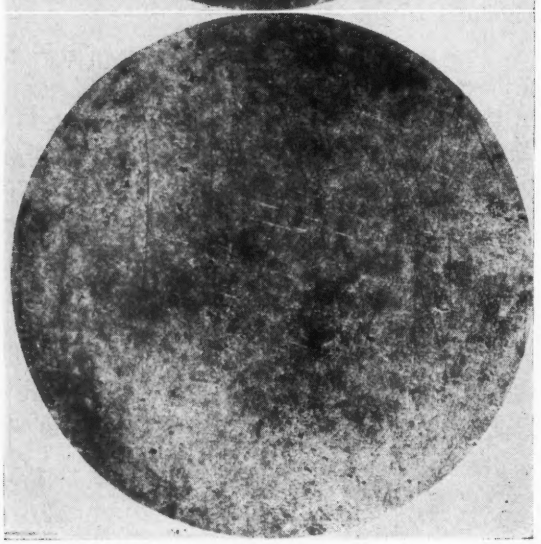

Fig. 4.

Fig. 2.—The surface of a copper die metallized by oil of bitter almonds and bronzing powder. (×10.) The surface is typical of most powder-liquid methods.

Fig. 3.—The surface of a copper die metallized by Aqua-Dag. (×10.) This was the best of powder-liquid techniques.

Fig. 4.—The surface of a copper die metallized by the precipitation of silver.

were obtained with Aqua-Dag, Fig. 8. The photograph again shows the difference in color in various areas due to the uneven retention of graphite following cleansing of the die.

The results secured by the use of the silver film are shown in Figs. 9 and 10 (because of the color, these photographs do not depict the actual great superiority of these dies). The reproduction is almost flawless. The higher magnification of

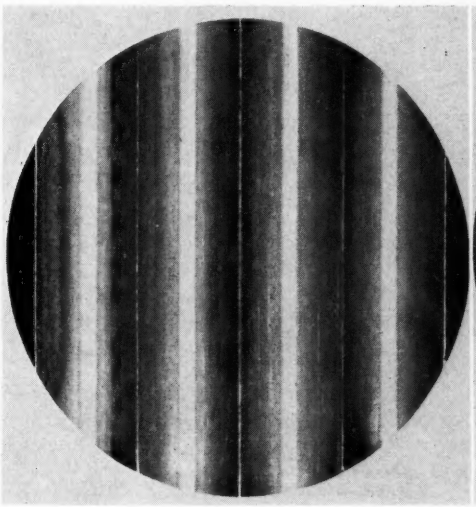

Fig. 5

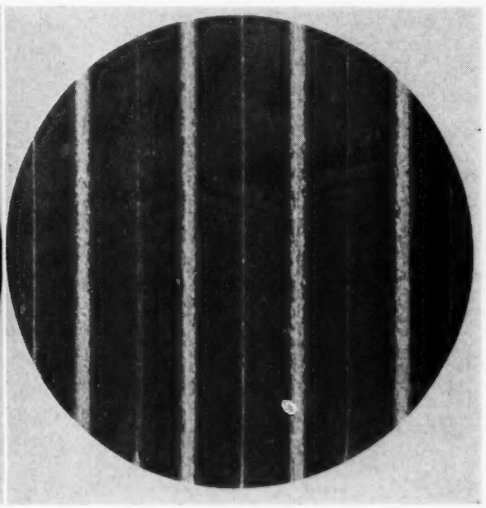

Fig. 6

Fig. 5.—The surface of a serrated master steel die. (×9; reduced 1/11.)
Fig. 6.—The surface of a typical compound impression. Note that this is the reverse of the surface shown in Fig. 5. (×9; reduced 1/11.)

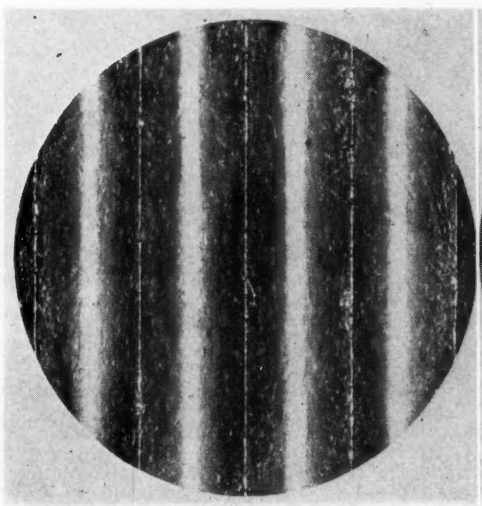

Fig. 7

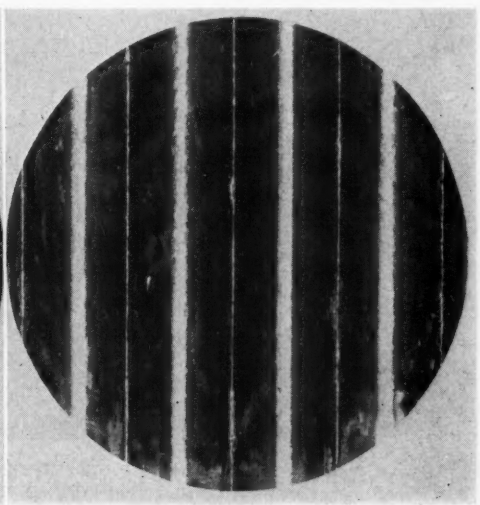

Fig. 8

Fig. 7.—The surface of a die metallized by oil of bitter almonds and bronzing powder. The lack of sharp reproduction is evident both on the knife edges and on the broad depressions. (×9; reduced 1/11.)
Fig. 8.—The surface metallized by Aqua-Dag. (×9; reduced 1/11.)

a typical silver surface, Fig. 10, compares most favorably with the surface of the original steel die. It has sometimes been stated that silvering solutions have a deleterious effect on compound.[4] This is true only if ammoniacal silvering compounds, such as in the Brashear or Rochelle salt process,[10] are used.

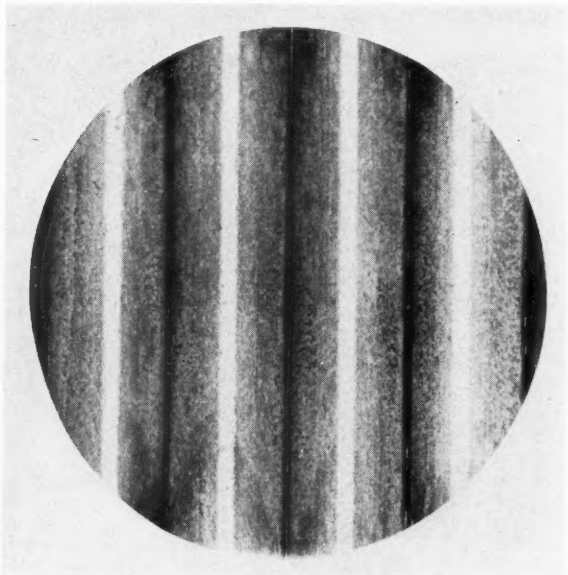

Fig. 9.—The surface metallized by precipitation of silver film. (×9.)

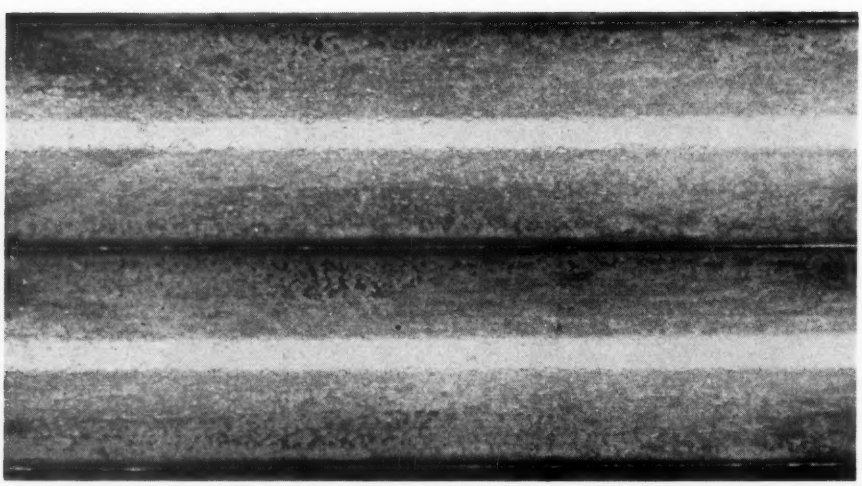

Fig. 10.—Higher magnification (×18) of the surface shown in Fig. 9. Note the continuity and fine detail of the edge.

DISCUSSION

The powder-liquid methods of metallization have several limiting factors. First, there is a variation in particle size of the powder which affects the surface smoothness. The metal deposit is so fine that it coats the irregular surfaces of the indi-

vidual particles. When the impression is deep, it is not possible to control the amount of powder left in the impression because it is impossible to burnish the surfaces adequately and thus remove all the excess. Considerable practice is necessary to do a good job of burnishing and, when using either oil of bitter almonds or Silbryte, to know when to apply the powder. In comparison with the silver film, the powder-liquid methods also have some surface tension difficulties; this problem can be minimized, however, by care in introducing the metallized impressions into the plating bath.

When used correctly, Aqua-Dag produces a good surface and quite accurate reproduction of the impression but, because of the retained graphite, would not be acceptable to some operators, especially those who utilize the electroformed die for anterior jacket crown construction. The silver film, as seen in the photographs of both the flat and serrated surfaces, was unquestionably the most effective metallizing technique of those studied.

During the course of this investigation (and in the subsequent clinical trial of the silver-film method*) it was noted that although metallized impressions of molar or bicuspid preparations routinely plated excellently, some difficulty was occasionally experienced with anterior jacket crown preparations. This has always been a problem in copperplating, regardless of the metallizing technique employed. Texts on electrodeposition contain many formulas for copperplating; however, the requirements for dental use are considerably different from those of industry. Little research has been done to evaluate the effect of the composition of the plating solution in the plating of dental impressions. Therefore, a series of tests were designed to shed some light on the influence exerted by the individual constituents and by their concentration.

A nickel-steel tapered die, having the approximate configuration of a large, long, anterior jacket crown preparation, was fabricated. All metallizing was done by means of the silver-film technique. Two hundred fifty impressions were plated during the course of this phase of the study. Four identical cells were constructed, and all variables such as current, cathode-anode distance, etc., were standardized.

Solutions of four different compositions were employed in the various cells. The compositions were arbitrarily selected, but were designed to indicate the influence of the various ingredients and were based upon some observations that have been made previously. The concentrations of the following ingredients were varied for each cell: copper sulfate, sulfuric acid, and phenol.

Five dies were plated, singly, in each cell for 30 seconds. They were then removed, examined, plated for an additional 30 seconds, removed, examined, and then plated and examined at one-minute intervals up to an elapsed plating time of five minutes. The solutions were then allowed to age for five days and the tests repeated. New solutions were also prepared, and each day small amounts of the deficient ingredients were added and dies plated. Eventually all four cells were brought to the same composition.

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*Carried out in the Crown and Bridge Department, Indiana University School of Dentistry, under the supervision of Drs. John F. Johnston, Roland Dykema, and D. M. Cunningham.

It must be realized, of course, that alterations in current density, agitation, and cathode-anode distance would definitely influence the character of the deposit and the throwing power in all four solutions. By controlling these variables, however, it was possible to make some definite observations concerning the effect of the various chemicals, per se, which make up the bath. They can be summarized as follows:

Phenol and Ethyl Alcohol.—Phenol has no visible effect on the character of the deposit or the time required to obtain full coverage. The addition of small quantities of additive agents such as phenol and ethyl alcohol does, however, increase the hardness and ductility of the copper.[16, 18, 19]

Acid.—As the concentration of acid is increased, the conductivity of the solution is raised, but the solubility of the copper sulfate is decreased. It is possible to electroplate without actually adding copper sulfate, merely by plating directly from the anode. However, the quality of the plate is inferior, and no build-up of the deposit can be achieved. Maximum throwing power is attained when the acid content is high and the sulfate or metal concentration is low.

Copper Sulfate.—This chemical determines the ionic metal content of the solution and the more metal present, theoretically at least, the more copper available for deposition at the cathode. Since the effect of adding metal to the solution is to reduce conductivity, the throwing power is reduced, but the build-up of the plate is enhanced.

Aging.—The effectiveness of the solutions was improved by allowing them to stand for several days. Authorities do not know why this phenomenon occurs, but it is thought that the additive agents form intermediate compounds and complexes and several days are required for stabilization.[14, 16, 18, 19]

Another series of tests were conducted to corroborate these observations, and to secure more quantitative data in regard to the actual depth of the deposit as it would be influenced by the constituents of the solution and by aging. Five holes, 0.25 inch diameter, were cut to varying depths ranging from 5 mm. to 20 mm. in a plastic block. Throwing power was thus measured by the depth of deposit in the various holes. The solutions used were similar to those employed in the preceding tests with the exception that somewhat more dilute and concentrated solutions were also included for evaluation.

The influence of adding copper sulfate to the control solution can be seen in Fig. 11. It is obvious that throwing power is excellent when the copper sulfate content is low; however, the character of the plate was decidedly inferior. Although the throwing power under these test conditions does decrease with the addition of copper sulfate, optimum results from the standpoint of the character of the plate were secured at a concentration of approximately 225 Gm. Conversely, the addition of sulfuric acid (Fig. 12) increases the throwing power. Maximum throwing power was attained at 75 ml. of acid with additional amounts actually reducing the depth of the deposit. The influence of aging upon the solution is seen in the chart in Fig. 13. The throwing power is definitely increased by aging. From these data it is also apparent that when the solution contains phenol, a longer time is required for stabilization.

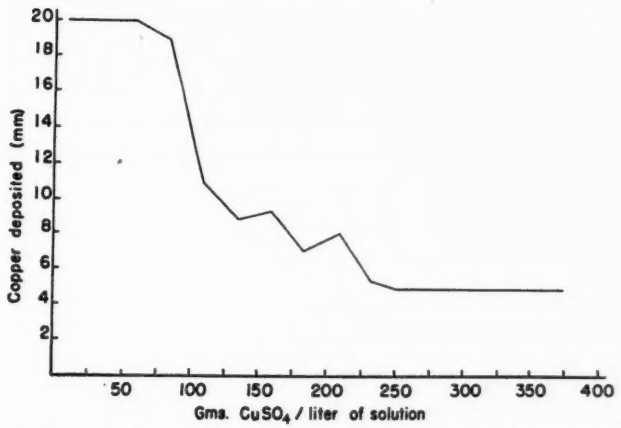

Fig. 11.—The influence of copper sulfate concentration on throwing power.

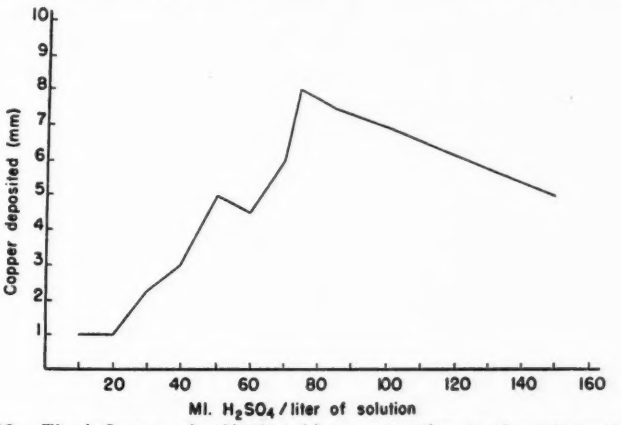

Fig. 12.—The influence of sulfuric acid concentration on throwing power.

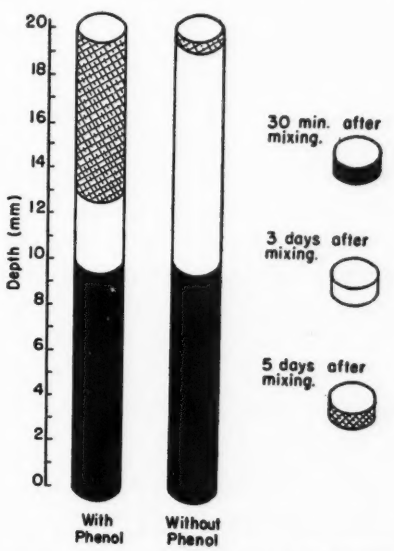

Fig. 13.—The influence of various aging periods upon solutions with and without phenol.

From the foregoing discussion it is obvious that some compromise must be reached for arriving at the proper composition to achieve optimum results. For example, if a low acid-high sulfate bath is employed for good build-up, the throwing power is so diminished that a dental impression could not be electroformed. Conversely, if a high acid-low sulfate composition is used, the throwing power is good but the deposit builds up too slowly, if at all. Although the optimum composition of the bath for plating the dental impression is not known, this investigation suggests the following formula:

Copper sulfate, anhydrous	225-250 Gm.
Sulfuric acid, concentrated	75 ml.
Phenol	10 ml.
Ethyl alcohol	25-50 ml.
Distilled water	1,000 ml.

This solution is allowed to stand for several days after mixing. A cathode of a scrap piece of copper or brass is placed in the bath and plated at a high current density for several hours. This "working" of the solution is another aid,[14, 16, 18, 19] to improve the performance of the solution.

This particular formulation has been employed for two years in the Crown and Bridge Clinic at Indiana University with excellent results. No plating difficulties have been experienced.

Oftentimes, certain types of plating failures can be eliminated by altering the composition of the bath. For instance, on a small anterior impression, burning of the deposit can be remedied by lowering the current density or by the addition of copper sulfate to the solution. Spotty coverage in the depths of the impression may be due to low acid content.

SUMMARY

The influence of five popular metallizing techniques in reproducing surface smoothness and marginal accuracy of compound impressions has been studied. Although careful use of all procedures did produce consistent and acceptable copper dies, the powder-liquid methods resulted in some loss of smoothness and detail. The precipitation of a silver film proved to be the superior method. Studies were made to determine the influence of the various constituents of the copperplating bath upon the throwing power, rate of coverage, and the character of the deposit. The theory behind the results obtained has been presented and a formula suggested.

It must be remembered that even in industry many steps in the electroplating procedure are based upon empirical observations. Consequently, the apparatus, techniques, and conditions in the dental office are seldom identical. The operator must, therefore, have a working knowledge of the basic factors involved so that he may intelligently alter his procedures and equipment as required.

Due to JOURNAL space limitations much of the detail concerning the actual research procedure and data was condensed or deleted.

We wish to acknowledge the technical consultation of Mrs. Jeanetta Peacock of the Industrial Oils Laboratory, various members of the engineering staff of the Radio Corporation of America, Dr. John DuMond, Gary, Indiana, and Dr. John F. Johnston and staff, Drs. G. A. Hiatt, Buffalo, New York, and M. R. Markley, Denver, Colorado, for their assistance in the clinical tests made.

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MAXILLOFACIAL PROSTHESIS WITH MAGNETIC STABILIZERS*

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University of Montreal, Montreal, Quebec

THIS is a report of a case involving the prosthetic repair of palatal-facial defects, resulting from the surgical treatment of a papillary epithelioma of the right maxillary sinus.

CASE HISTORY

Mrs. E. B., a 55-year-old edentulous white woman, presented herself for treatment of a "growth" on the right maxilla. In 1950 the patient first noticed a small nodule, which gradually increased from the size of a pea in 1950, to that of a prune in 1951. A year later, in September, 1952, there was a perforation of the hard palate.

Diagnosis.—Alveolar epithelioma of the salivary gland in June, 1952; a papillary epithelioma vegetans in October, 1952, of the right maxillary sinus.

Fig. 1.—Appearance of the face after healing. Note the depression of the cheek and of the upper lip.

Therapy and Prognosis.—A Caldwell-Luc operation was performed. The right maxilla was removed with evisceration of the orbit on Oct. 10, 1952 (Figs. 1, 2, 3). Irradiation therapy was given from Nov. 13 to Dec. 12, 1952. The patient was examined again, and no recurrence was noted until Nov. 12, 1953.

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*H. Freedman's magnetic stabilizers.

**Head of the Department of Prosthesis, Faculty of Dental Surgery.

In January, 1954, little growths in the surgical cavity were noticed and, on Feb. 18, 1954, electrocoagulation of the cavity was performed. There was no recurrence and the patient was in good health, but under constant observation. The patient was referred to us then for rehabilitation.

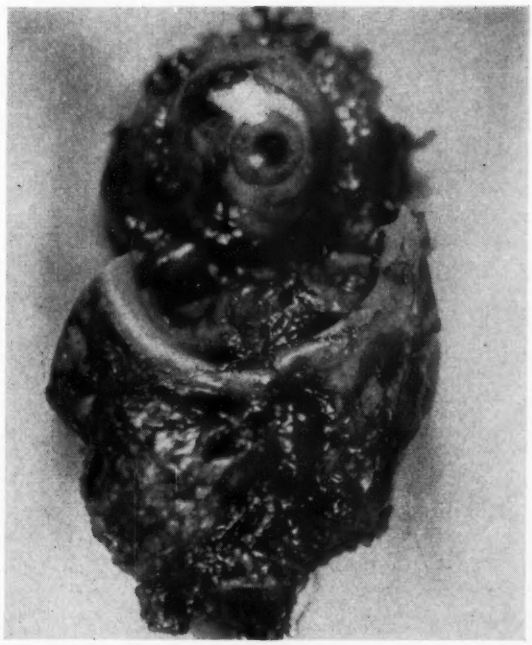

Fig. 2.—The tumor and eye after removal.

Fig. 3.—Opening in the face where the sphenoidal fissure may be observed posteriorly.

TECHNIQUE

Preliminary impressions of the mouth were made (Fig. 4) in order to build individual trays which would make possible satisfactory impressions of the remaining tissues and also part of the surgical cavity.

These individual trays were stabilized and used as baseplates for the registration of all measurements, and a setup of the teeth was made for a try-in. An impression of the surgical cavity was then made by external access while the baseplates were in the mouth.

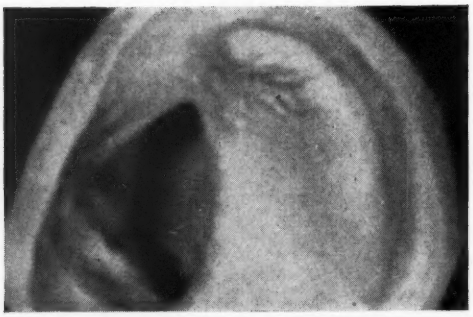

Fig. 4.—A cast from the preliminary impression showing the loss of structure.

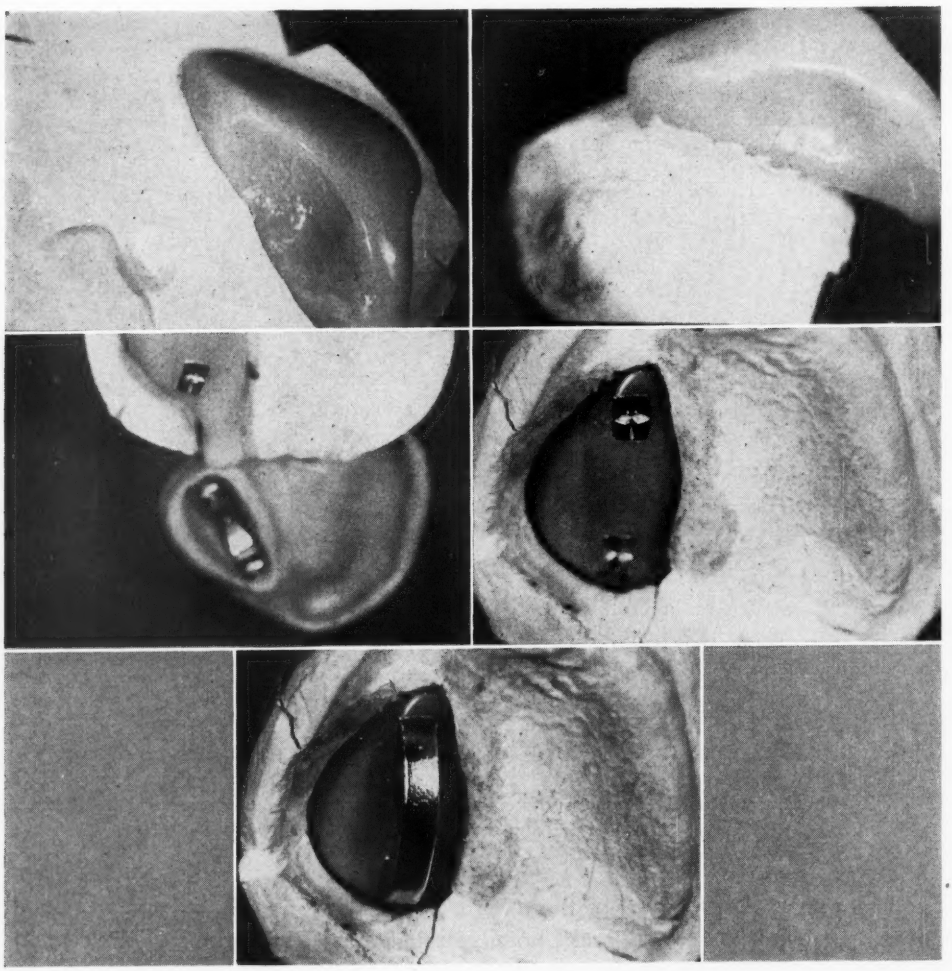

Fig. 5.—*A*, The obturator partially removed from the sectional cast.
B, The obturator in position on the final upper impression.
C, The denture hollowed out to receive the magnet which will be attracted to the one already in position in the obturator.
D, The obturator repositioned in the cast.
E, The magnet held in position on the obturator to determine its position in the denture. It is retained in the denture by plaster. Then self-curing acrylic resin is substituted for the plaster.

When the impression of the surgical cavity had set, it was separated from the upper baseplate and removed through the external cavity. A stone cast was made of three sections to facilitate the flasking of the obturator, and its removal from the cast after curing. After the obturator was adjusted and polished, a hole large enough to receive one magnet was made inside it from the palatine surface. One third of that hole was filled with a fast-setting plaster, and the obturator was inserted in the surgical cavity. From the inside of the mouth, the magnet was held in place with its two poles parallel to the palatine surface until the plaster hardened

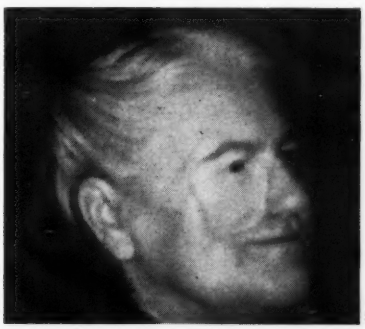

Fig. 6.—The complete restoration.

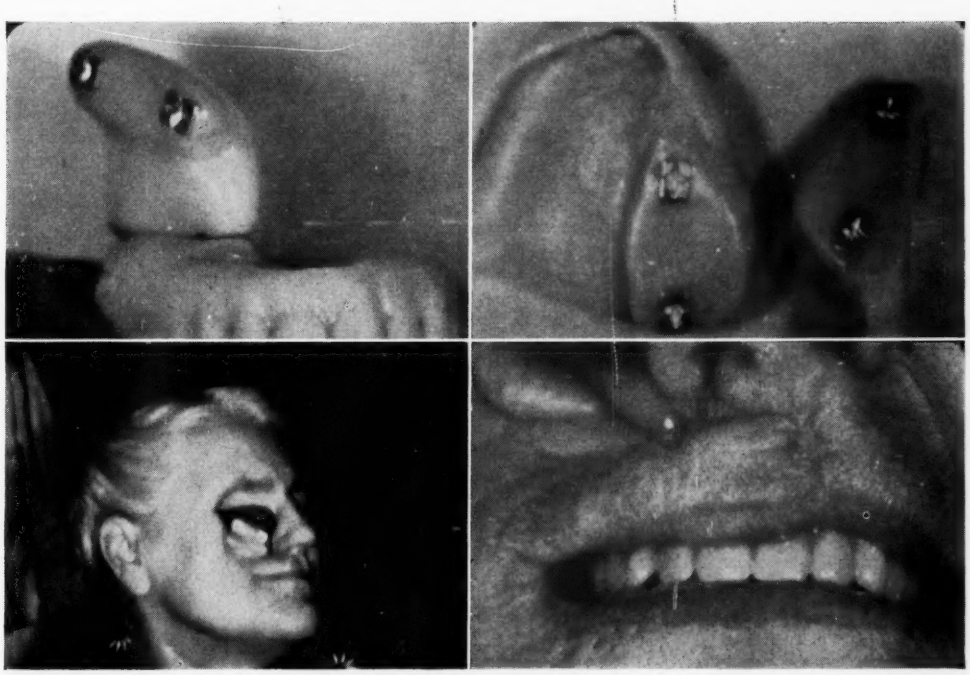

Fig. 7.—*A* and *B*, Upper denture with the obturator. *C* and *D*, Insertion of the dentures and the obturator.

(Fig. 5). After removal from the cavity, a stone matrix was made over the protruding poles of the magnet. After the stone had set, the plaster was removed from the cavity and replaced by a soft mix of self-curing acrylic resin. After the resin hardened, the matrix was removed, and the remainder of the cavity in the obturator was filled with self-curing acrylic resin and polished.

The final impression of the lower arch was made in a zinc oxide and eugenol impression material by means of a closed-mouth technique, and the lower denture was processed.

The upper baseplate was made hollow in the part facing the obturator so as to make space for a second magnet to be placed in the upper base. A zinc oxide and eugenol impression material was used in the upper baseplate to make an impression of all of the bearing tissue areas, and plaster was used to make the upper impression in the magnet area. The upper denture, with a magnet insert, was processed.

The pattern for a facial prosthetic appliance was waxed on a cast made from a facial mask impression, and a plastic artificial eye was inserted in the wax pattern before the try-in. Then the facial prosthetic section was cured (Fig. 6).

Fig. 8.—The denture, obturator, and external appliance assembled and held together by magnets

Fig. 9.—The three components of the restoration. Note the positions of the four magnets.

Before the patient was dismissed, two more magnets were added in a horizontal position on the upper part of the obturator. The poles of one magnet faced the external section, and the poles of the other faced the inside surface of the facial appliance (Fig. 7). In this manner, the three upper parts were held together by the four magnets (Figs. 8, 9).

SUMMARY

The use of "magnetic stabilizers" has proved to be of great value in maintaining and stabilizing facial prostheses related to oral prosthesis. A complete evaluation can be made only by an analysis of all of the resultant factors: (a) the restoration of mastication, deglutition, phonation, and esthetics, (b) the general psychologic improvement and improved morale values.

Maxillofacial prosthesis, in order to be functional, should be of a very simple design, with ease of manipulation for the patient. The use of magnets for stabilizing these restorations can make them simple and effective. Accordingly, the well-being of many patients is further assured and on a sound basis.

Acknowledgment of photographs is made to Dr. Jean Fontaine of the Faculty of Dental Surgery of the University of Montreal, and also to the Notre Dame Hospital Photography Department.

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INTERNAL NASAL PROSTHESIS

Louis J. Boucher, D.D.S.,* Leslie Wilde, D.D.S.,**
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THIS REPORT IS of a 27-year-old white male veteran who was first seen in April, 1953, in consultation with the Plastic and Maxillofacial Service. At that time he was wearing an unsatisfactory prosthetic nose. The Plastic Surgery Service recommended a full plastic reconstruction of his nose. Having undergone thirty-six previous operations on his nose and face, the patient refused extensive surgical reconstruction.

SURGICAL HISTORY

The patient was struck by shrapnel on Saipan in 1944 and sustained a disfiguring injury to the nose and palate. He underwent several operations in the Great Lakes Naval Hospital from 1944 to 1946. These included flap transplants from the left arm and from the temporal region, as well as cartilage implants. In 1946 and 1947 at the National Naval Medical Center, Bethesda, Md., further cartilage implants were attempted. In addition, scar tissue about the nose was excised in an attempt to facilitate breathing. Subsequently, his private surgeon chiseled down the nasal bone and attempted additional cartilage implantation. All of these cartilage implantations were unsuccessful, the cartilage sloughing out in each instance.

PHYSICAL EXAMINATION

Physical examination revealed a well-developed, well-nourished white man with obvious disfigurement of the nose (Fig. 1). There was a left frontal skin flap scar with a healed skin graft, and scars on the lower jaw. The left eye was totally blind and exotropic, with no reaction of the pupil to light. The right pupil was larger than the left and reacted normally to light and accommodation. There was a scar in the left clavicular area. There were healed donor site scars in the left lower quadrant, over the right anterior iliac crest, and over the left biceps. The nose was completely occluded by scar tissue which prevented the passage of air. There was loss of the tip, septum, and the columella on the left side. The flattening and atresia of the nose and nostrils appeared to result from both insufficient lining and incomplete external flap tissue. There was a midline oronasal fistula with central loss of the premaxillae, teeth, vomer, and adjacent septum.

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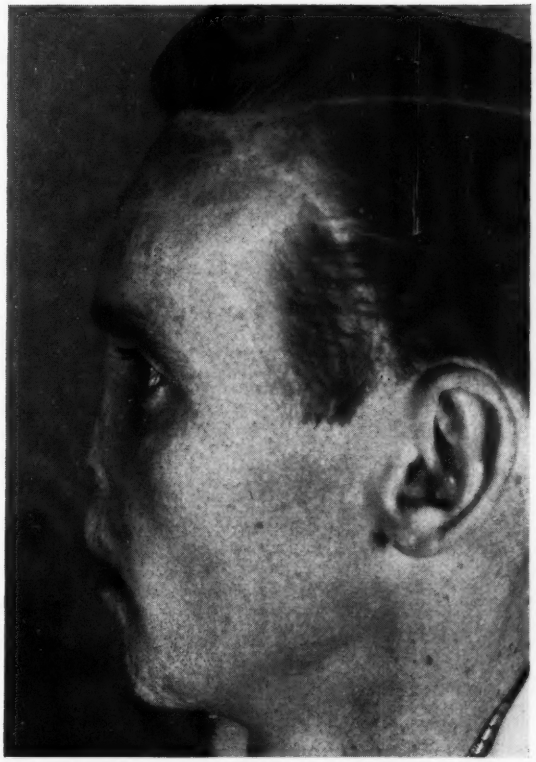

Fig. 1.—Left lateral view of patient before plastic and prosthetic procedures.

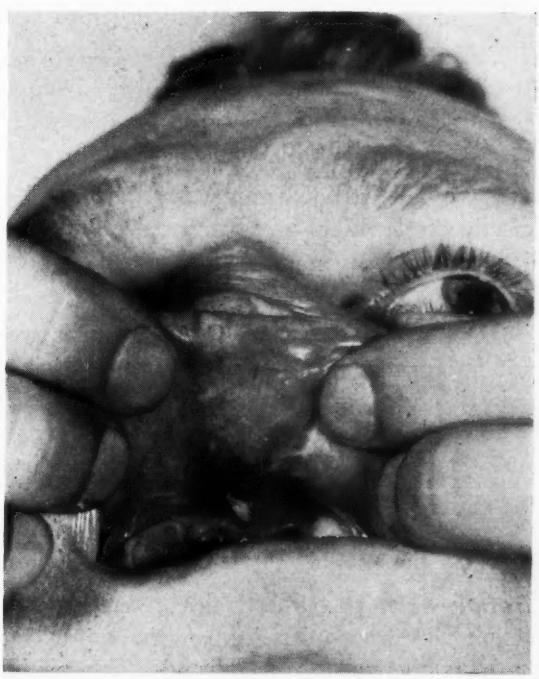

Fig. 2.—Anterior view demonstrating oronasal orifice.

DENTAL EXAMINATION

A 1.5 cm. palatal defect, which communicated with the nasal cavity, was covered by an upper partial denture (Fig. 2). There were no signs of inflammation in this region. The remaining upper teeth included the cuspid and second molar on the right, and the second and third molars on the left, all of which were carious. In the lower jaw was a retained root in the region of the left first bicuspid. Scar tissue was present on the lower left alveolar ridge and buccal sulcus. Four of the remaining eight lower teeth were carious. The patient had a lower partial denture which was unserviceable due to the presence of scar tissue.

TREATMENT PLAN

Because of the patient's desire for only limited surgery, the following treatment plan was formulated:

1. A complete dental examination was to be made, which would include roentgenograms and study casts properly articulated and surveyed, to ascertain the proper type and shape of tooth restorations and partial denture design.
2. Outside-inside impressions were to be made, and a positive likeness processed in a soft plastic material which could be split in half for use as a study model.
3. A nasal stent would be fabricated which could be inserted into the nasal cavity through the palatal defect to prevent shrinkage of a split-thickness skin graft.
4. The nasal cavity would be lined with a split-thickness skin graft to prevent stenotic scarring.
5. The columella would be lengthened.
6. A second nasal stent would be fashioned which could be extended periodically to stretch the skin of the nose anteriorly, in order to approach the correct nasal form, and to maintain an adequate airway.
7. The columella would be attached to the tip of the nose.

PROCEDURE

Operative Dentistry.—The retained root was removed, all carious teeth were restored, and all defective restorations were replaced. The three upper abutment teeth were restored with gold crowns. A buccal retentive groove was placed in the gold crown of the upper right second molar.

The Original Stent.—An inside-outside impression, as well as a face mask impression, was made in alginate. A stone cast was poured in the face mask impression. A pliable plastic model was processed from the inside-outside impression. This was cut in half through the midline and used as a study model. From these models, the size and shape of the acrylic resin stent to be constructed were determined. An impression of the palatal defect and nasal cavity was made, and casts were poured. An acrylic resin stent (Fig. 3, left) was processed. This stent rested on the palate, filled the palatal defect, and extended into the nasal cavity.

The Partial Denture.—For proper esthetics, retention, stability, and path of insertion, a back-action clasp was placed upon the upper right cuspid, and a circumferential clasp upon the upper right second molar, with the retentive arm

falling into the buccal groove which had been placed in the molar crown. A circumferential clasp was placed around the upper left second molar. The anterior labial flange was built out to give a more normal contour to the asymmetrical upper lip. The final impression was made with the nasal prosthesis in place. When the base of the nasal prosthesis and a satisfactory partial denture to hold it securely in place were completed, the patient was ready for operation.

Fig. 3.—Left: Lateral view of acrylic resin stent before the compound addition was made. Center: Stone model of the acrylic resin stent and the compound addition (crossed hatched). Right: The acrylic resin stent with a hinge on top which can be opened after the stent is in place.

PLASTIC SURGERY

On Oct. 14, 1953, under general endotracheal anesthesia, the oronasal fistula was enlarged by lateral incisions, and the bony margin spicules were removed. The small columella was severed at its attachment from the free portion of the nose. In the resection, flaps of lining skin from the inferior septal area were preserved, and so fashioned as to double the columella in its length and to retain portions of cartilage within it. The columella was closed with flaps presenting exterior skin or mucous membrane, but the free end was not attached to the "tip" area of the nose at this stage. All lining tissues of the atresic nostrils were opened by denuding the anterior area of the nose, and creating a pocket subcutaneously between the nasal skin and the remaining bony framework superiorly (Fig. 4). This pocket was to receive the superior portion of the nasal prosthesis. Since a properly fitting modeling compound addition was to be made to the acrylic resin stent during the operation, the plastic surgeon described the size and shape of the necessary addition, and the prosthodontist constructed the addition in the operating room. Since a flame could not be used, sterile hot water was poured over green stick compound which was added to the stent (See Fig. 3, center). A 14/1,000 thickness 3.0 by 6.0 cm. graft was cut from the inner aspect of the right upper arm by dermatome. The skin graft was draped over the nasal prosthesis with the raw side out, and held in place to the stent by rubber cement. The stent was inserted through the oronasal fistula with the superior portion in the subcutaneous pocket. The partial denture, which secured the nasal prosthesis securely, was then inserted.

The oropharynx was aspirated at the end of the operation and the patient was given a 500 c.c. replacement blood transfusion. He tolerated the procedure well.

On the first day postoperatively, the patient was fed by tube and the moustache petroleum jelly dressing was changed. The second day there was no drainage. The donor site was satisfactory and the patient was started on a liquid diet. The moustache petroleum jelly dressings were changed daily. On Oct. 23, 1953, the oral surgeon gave the patient an extraoral, second division, fifth cranial nerve block to permit the removal of the nasal prosthesis without disrupting the skin graft, and without discomfort to the patient. The split graft was found to have attached completely.

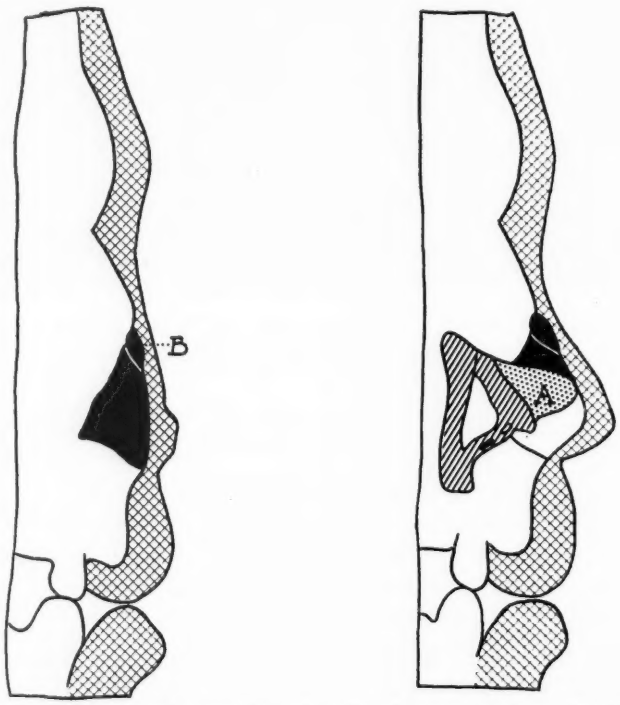

Fig. 4.—Preoperative and postoperative pictures of x-ray tracings, showing the relationship of the prosthesis to bone and soft tissue. Diagonal lines represent the gold portion of the nasal stent; *A* represents the acrylic resin addition which is placed through the right nostril; the shaded portion represents scar tissue; and *B* represents a mobile fragment of bone at the base of the nasal bones.

ADDITIONS TO THE STENT

From October, 1953, to February, 1954, more modeling compound was added to the stent at weekly intervals. Subsequently, acrylic resin was substituted for this modeling compound. The skin of the nose was gradually displaced anteriorly by this process. Only small amounts of modeling compound were added each time, in order to avoid pressure necrosis. Finally, the stent would no longer go through the oronasal fistula because it was too large for the orifice. An acrylic resin stent was then fashioned with a hinge on top which could be opened out after it was in place (See Fig. 3, right). Additions were made to this stent until it would no longer go through the palatal orifice. A nasal prosthesis with a double hinge was then made

of gold. This gave insufficient anterior extension to the nose because of the geometric limitations of an arc. Thus, although the dorsum of the nose was raised, the tip was not. The upper extension was removed and the lower extension was redesigned (Fig. 5), to receive an acrylic resin addition, which was placed through

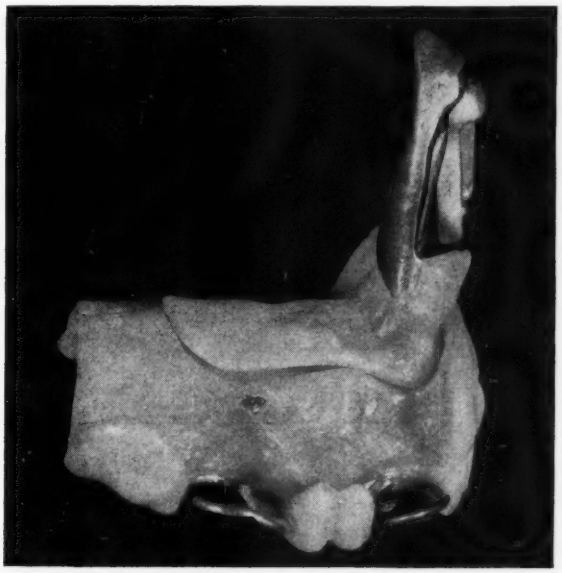

Fig. 5.—The gold nasal stent with the acrylic resin base resting on the palatal portion of the partial denture. The extension of the stent is closed as it would be when it is being inserted through the oronasal orifice.

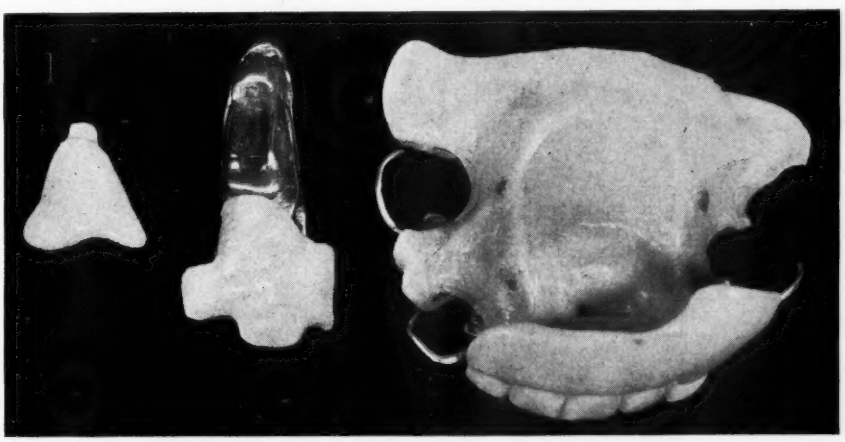

Fig. 6.—Anterior view of the three separate parts of the prosthesis—the acrylic resin addition, the nasal stent, and the partial denture.

the right nostril (Fig. 6 and 7). This proved to be satisfactory, as the patient was able to manipulate it without discomfort or difficulty. Additions to this acrylic resin were made until the best possible nasal contours could be attained. The skin on the right side could be stretched further but, because of the constricted, thick scar tissue on the left side, no more additions were made (Fig. 8).

Fig. 7.—Lateral view of the partial denture supporting the extended nasal stent, which is carrying the acrylic resin addition. The nasal stent was not fully seated on the partial denture to demonstrate the line of demarcation between the base of the stent and the partial denture.

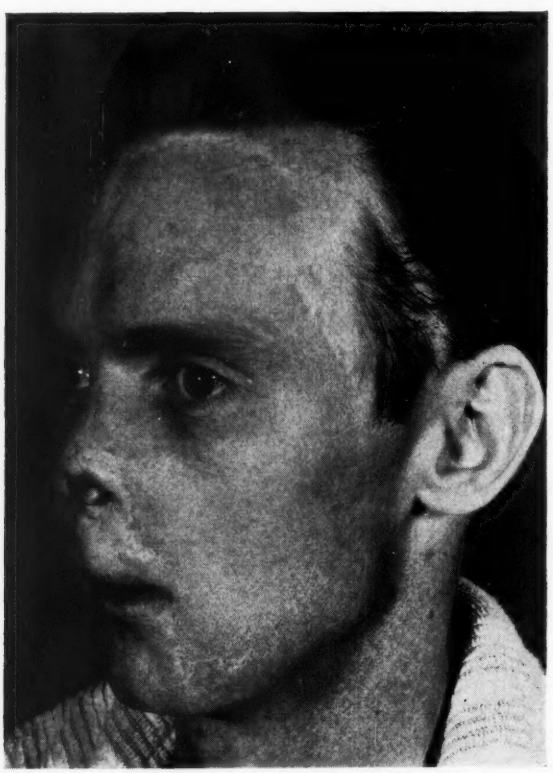

Fig. 8.—The nasal stent in place before the attachment of the columella.

ATTACHMENTS OF THE COLUMELLA

On Feb. 24, 1954, under local anesthesia, a previously fashioned columella was attached to the tip of the nose. On March 2, 1954, all sutures were removed from the site of the attachment of the columella (Fig. 9). Examination on April 2, 1954, showed adequate healing.

On Aug. 23, 1954, the patient had a cosmetic revision of the columella with the removal of excess tissue.

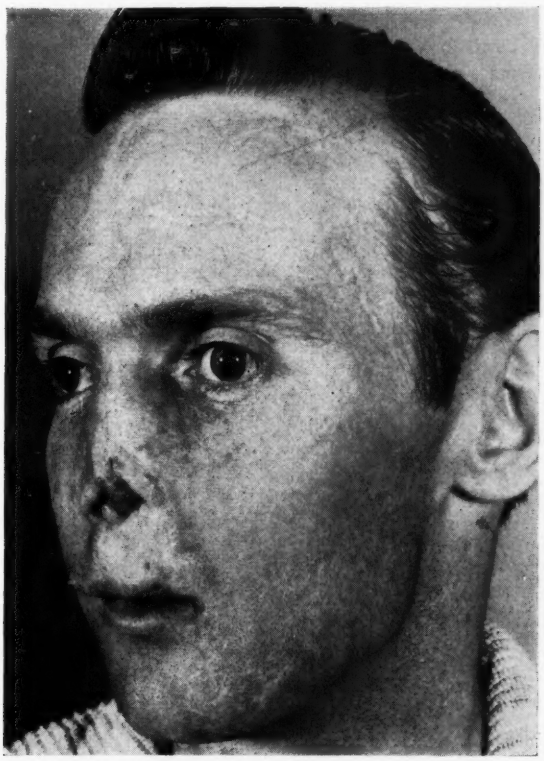

Fig. 9.—The patient without the nasal stent six days postoperatively.

RESULTS AND PROGNOSIS

The partial denture fulfills the requirements of esthetics, function, retention, and stability, and makes secure the nasal stent. The nasal stent is comfortable and can be manipulated by the patient without difficulty (Fig. 10). The patient can breathe through his nose and is satisfied with the improvement in his appearance (Fig. 11), so that he has discarded both a masking bandage and his external nasal prosthesis.

On the last examination in April, 1955, there was no evidence of irritation. The prosthesis is expected to be satisfactory for many years. Should the patient lose his upper teeth, a complete denture could be fitted over the stent.

Fig. 10.—The nasal stent in place. The projection from the base of the stent serves as a handle for removing the stent. Note the increase in nostril size and lengthened columella.

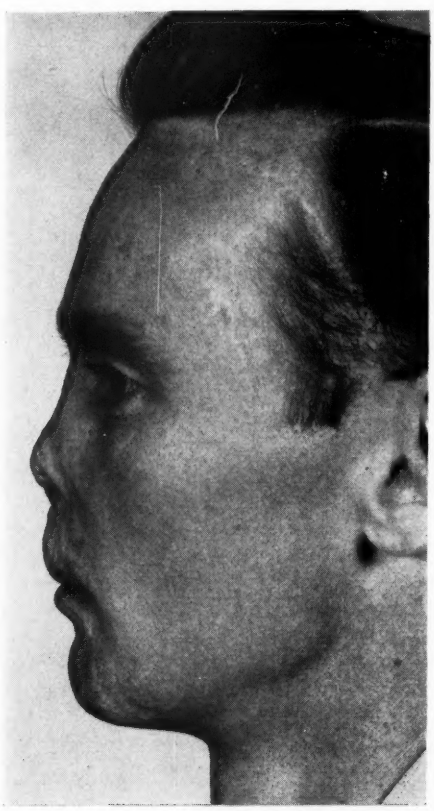

Fig. 11.—Left lateral view with prosthesis in place.

SUMMARY

A case of traumatic deformity of the nose and premaxillae is presented. Because the patient refused extensive plastic reconstructions, a series of limited operative procedures were carried out to improve his airway and appearance. The basis for these improvements was the utilization of an internal nasal prosthesis.

Appreciation is expressed to the following for their cooperation: Dr. Ross C. Kory, Chief, Investigative Medicine; Dr. E. J. Shields, Oral Surgeon; Dr. J. P. McCormick, Operative Dentistry and Crown and Bridge Procedures; Howard Shearer, Dental Laboratory Technician; Mr. Sigurd Orum, Chief X-ray Technician; Mr. Pierre J. LeDoux, Chief, Medical Illustration; Mr. George Spuda, Medical Illustrator; and Mr. Morton Blatt, Medical Artist, all of the Veterans Administration Center, Wood, Wisconsin.

Dental Service
Veterans Administration Center
Wood, Wis.

Book Review

FIXED PARTIAL PROSTHESIS, By Joseph E. Ewing, D.D.S. First edition, 208 pages with 482 illustrations. Philadelphia, 1954, Lea and Febiger. Price $6.00.

This book is a compact and useful presentation of clinically satisfactory methods and techniques in the construction of crown and bridge prostheses. While apparently the contents have served as the basis for undergraduate teaching (the author is professor of crown and bridge prosthesis at Temple University School of Dentistry), the text is still of value to, and contains much of pertinent interest for, the general practitioner.

The organization and chapter continuity is quite logical, and although there is no index, permits ready reference. The sequence in the construction of crowns and bridges is well arranged. This includes clinical and radiographic diagnosis; preparations for retainers; various types of full crowns, veneer crowns, dowels, inlays, and stress-breaker connectors. Restoration design also is given adequate attention, as are the indications and contra-indications for fixed partial restorations.

Important items, sometimes ignored in such texts, such as insertion, removal, and repair of crowns and bridges; protection of abutment teeth; soldering, investing, and casting, are described in a how-to-do-it manner that should prove most helpful to the student and practitioner.

Practically all of the illustrations are diagrammatic drawings that serve amply to point up the author's methods of techniques. The descriptive text is in a somewhat telegraphic and step-by-step style that makes for easy understanding and study.

It is likely that this book will go into another edition. In that event, both author and publisher should be a little more proof-reading conscious. This reviewer could not help noting the many typographical errors and inconsistencies in spellings. These, while annoying to an ex-editor, still do not detract from the general usefulness and value of this publication.

T. F. McBride

AMERICAN BOARD OF PROSTHODONTICS

S. Howard Payne, D.D.S.

School of Dentistry, University of Buffalo, Buffalo, N. Y.

THE LAST EXAMINATION of The American Board of Prosthodontics was held June 20 to 25, 1955, at Marquette University School of Dentistry, Milwaukee, Wisconsin. Sixteen candidates successfully met the Board requirements and have been certified to practice the specialty of Prosthodontics.

After serving this past year as president, Dr. Harold L. Harris goes off the Board. He and Dr. Homer Simpson, who also retired this year, have contributed unselfishly to the accomplishments of the past several years.

The next examination will be held at Marquette University School of Dentistry in September, 1956. Those desiring to make application to the Board should address the secretary.

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FOURTH ANNUAL ESSAY CONTEST

Sponsored by

THE AMERICAN DENTURE SOCIETY

PRIZES WILL BE AWARDED to the two senior dental students who submit the best essays on prosthetic dentistry in the fourth annual essay contest sponsored by The American Denture Society. The purpose of the contest is to stimulate technical writing by dental students.

The first prize is Five Hundred Dollars ($500.00) and the second prize is Three Hundred Dollars ($300.00).

RULES

1. The contest is open to all senior dental students in the dental colleges of the United States and Canada.
2. Only two essays may be submitted from any one dental college. (It is recommended that each dental college conduct its own contest to determine the two best essays submitted by members of its senior class.)
3. All essays submitted in the contest shall be accompanied by a letter from the professor of prosthetic dentistry and/or the dean of the dental college from which they originate. This provision is to assure the authenticity of all essays entered in the contest.
4. For this year's contest, essays must be postmarked on or before July 15, 1956.

   It is recommended that students start preparing their essays by the middle of their junior year and complete them by the middle of their senior year.
5. Essays are to be on some phase of prosthetic dentistry, and limited to a maximum of 2,500 words.
6. Essays must be worthy of publication in the JOURNAL OF PROSTHETIC DENTISTRY.
7. Essays must be typewritten, double spaced, on a good grade of white bond paper 8½ by 11 inches. No carbon copies or essays on onion skin paper will be considered. Paragraphs must be indicated clearly by indentations, and generous margins must be allowed on each page.
8. Illustrations must conform to the standards of the JOURNAL OF PROSTHETIC DENTISTRY, if they are used. Only good glossy black and white photographic prints or drawings in India ink may be used. Each illustration should be mounted on a separate sheet of paper with the figure number and the legend typed on the paper beneath the illustration.

9. References must conform to the style used in the JOURNAL OF PROSTHETIC DENTISTRY.
10. Essays are to become the property of The American Denture Society. None will be returned.
11. The judges of the contest are members of a committee of The American Denture Society. The decision of the judges is final.
12. Essays are to be clearly marked "Contest Essay" and sent, with a letter from the professor of prosthetic dentistry or the dean of the dental college indicating that this essay is an official entry from the dental college, to:

Dr. Victor L. Steffel
Secretary-Treasurer, American Denture Society
College of Dentistry, Ohio State University
Columbus 10, Ohio.

Erratum

The President-Elect of the Pacific Coast Society of Prosthodontists was incorrectly listed in the Directory included in the November, 1955 issue. The President-Elect is Dr. George H. Chiles, 618 Professional Building, Phoenix, Arizona.

News and Notes

ANNOUNCEMENTS

The Midwinter Meeting of the American Denture Society will be held at the Congress Hotel, Chicago, Ill., Feb. 3 and 4, 1956.

The Annual Meeting of the American Academy of Crown and Bridge Prosthodontics will be held at the Conrad Hilton Hotel, Chicago, Ill., Feb. 4 and 5, 1956.

The Annual Meeting of the American Academy of Restorative Dentistry will be held at the Conrad Hilton Hotel, Chicago, Ill., Feb. 4 and 5, 1956.

The next Annual Meeting of the Pacific Coast Society of Prosthodontics will be held at Paradise Inn, Phoenix, Arizona.

The Annual Meeting of the Academy of Denture Prosthetics will be held at the Broadmoor Hotel, Colorado Springs, Colo., April 30 to May 5, 1956.

Northwestern University announces fifteen short postgraduate courses to be given during the academic year 1955-1956. Courses in Operative Dentistry, Oral Surgery, Periodontia, Orthodontics, Pedodontics, Crown and Bridge, Pathology, and Histology are included, as well as specific courses in diagnosis and medical problems in relation to dentistry. The courses will be given by prominent dental teachers from the faculties of Northwestern University Dental School and other well-known dental schools, and by prominent clinicians.

The dates of the courses and other detailed information can be obtained by addressing the Director of Dental Postgraduate Study, Northwestern University Dental School, 311 E. Chicago Ave., Chicago 11, Ill.

The Medical College of Virginia, School of Dentistry, announces a series of postgraduate courses of interest to general practitioners. These courses are given by the members of the faculty, unless otherwise designated.

Complete Denture Construction, Vincent R. Trapozzano	Jan. 23 to 28, 1956.
Crown and Bridge Prosthesis	Feb. 20 to 22, 1956.
Periodontics	March 5 to 9, 1956.
Oral Diagnosis	March 12 to 17, 1956.
Anatomy of the Head and Neck	March 19 to 23, 1956.
Oral Surgery	April 9 to 11, 1956.
Roentgenology	April 16 to 18, 1956.

For further information, write to S. J. Kreshover, Director of Postgraduate and Graduate Instruction, Medical College of Virginia, School of Dentistry, Richmond 19, Va.

New York University College of Dentistry announces three postgraduate courses in Periodontia and Oral Medicine, by Dr. Samuel Charles Miller and Staff.

No. 124—Refresher Course in Periodontia and Oral Medicine. Each Wednesday, 4 to 6 P.M., Feb. 29 to May 10, 1956.

No. 123—Periodontia and Oral Medicine in the Spanish Language, April 2 to 27, 1956.

No. 122—Comprehensive Preparation in Periodontia and Oral Medicine. This program is arranged in from one to four academic years.

For further information concerning these courses, write to the Secretary, Postgraduate Division, New York University College of Dentistry, 209 E. 23rd St., New York 10, N.Y.

The School of Dentistry, University of Pennsylvania, announces the following postgraduate courses:

Hydrocolloid Indirect Technic for Inlays and Bridges, Morris J. Thompson, Feb. 11 to 12, 1956.

Oral Surgery and Anesthesia, Thomas M. Meloy, Feb. 20 to 25, 1956.

Periodontal Prosthesis, Morton Amsterdam and D. Walter Cohen, Feb. 27 to March 3, 1956.

Crown and Bridge Prosthesis, Charles B. Sceia, March 5 to 10, 1956.

Complete Denture Prosthesis, M. M. DeVan, March 12 to 17, 1956.

Complete Denture Prosthesis, Victor O. Lucia, March 19 to 24, 1956.

Endodontics, Louis I. Grossman, April 12 to 27, 1956.

The Seventh Mid-Atlantic States Conference in Dentistry, Skytop Lodge, Skytop, Pa., Periodontal Prosthesis, Lester W. Burket, April 22 to 27, 1956.

For further information concerning these courses, please communicate with Postgraduate Courses, School of Dentistry, University of Pennsylvania, Philadelphia, 4, Pa.

The Department of Periodontia and Oral Medicine of New York University College of Dentistry announces its Annual Workshop on "Occlusal Equilibration" to be held June 11 to 15, 1956. For further information, write to the Secretary, Postgraduate Division, New York University College of Dentistry, 209 East 23rd St., New York 10, N.Y.

The Ohio State University College of Dentistry announces a series of postgraduate courses to be presented during the 1955-1956 school year. The enrollment of each course is limited, in order to permit intimate teaching.

The schedule of these postgraduate courses is as follows:

Anatomy of the Head and Neck, Dr. Linden F. Edwards, June 11 to 15.

Clinical Oral Pathology and Diagnosis, Dr. Hamilton B. G. Robinson, February 13 to 17.

Clinical Periodontics, Dr. John R. Wilson, June 11 to 15.

Complete Denture Prosthodontics, Dr. Carl O. Boucher, February 20 to 24 and April 9 to 13.

Crown and Bridge, Dr. Frank C. Starr, April 2 to 6.

Endodontics, Dr. J. Henry Kaiser, March 5 to 9.

General Anesthesia, Dr. M. L. Allison and Staff, May 21 to 25.

New Advances in Restorative Dentistry, Drs. William Lefkowitz, Harry Postle, and Mr. Ralph Phillips (Indiana University), May 10 to 12.

Oral Surgery, Dr. M. L. Allison and Staff, April 30 to May 4.

Partial Denture Prosthodontics, Dr. Victor L. Steffel, March 26 to 30.

Pedodontics, Drs. L. S. Pettit and Ben Williams, May 14 to 18.

Periodontology and Soft Tissue Lesions, Drs. Hamilton B. G. Robinson and John R. Wilson, June 4 to 8.

For further information and application, write to Postgraduate Division, College of Dentistry, Ohio State University, Columbus 10, Ohio.

The twenty-ninth annual Dallas Mid-Winter Dental Clinic will be held Jan. 22 to 25, 1956.

The Dental Department of Beth Israel Hospital in Boston announces two postgraduate courses in Periodontia.

Occlusal Adjustment, March 7 to 11, 1956.

Seminar in Periodontia, May 7 to 18, 1956.

For further information, write to Coordinator of Education Programs, Beth Israel Hospital, 330 Brookline Ave., Boston 15, Mass.

Dentists are being asked to cooperate with our Government in a campaign to ship overseas books and magazines which may be placed in foreign libraries. This is a most effective way to tell the American story to our friends and potential friends abroad. Technical, popular, and pictorial magazines, fairly well up-to-date and in good condition, and both technical and fictional books are in great demand in many areas of the world. They should be sent to the U.S. Book Exchange Inc., 1816 Half St., S.W., Washington 4, D.C. Packages sent to the Exchange can be mailed second class for 9 cents for the first pound, and 8 cents for each additional pound.

The University of Alabama School of Dentistry in conjunction with the Birmingham Veterans Administration Hospital offers a two year residency in Prosthetics, which can lead to the Master of Science degree in Dentistry, if desired. Applicants, due to Veterans Administration regulations, must be American citizens.

For detailed information, write to Joseph P. Lazansky, M.D., D.M.D., Associate Dean, Director of Graduate and Postgraduate Education, University of Alabama School of Dentistry, Birmingham 3, Ala.

Columbia University, School of Dental and Oral Surgery, announces a postgraduate course PD 429, Principles of Occlusion, May 23-25, 1956. Registration must be made by March 15, 1956. For further information, write to Columbia University Postgraduate Division, School of Dental and Oral Surgery, 630 West 168th St., New York 32, N.Y.

The Journal of Prosthetic Dentistry

Including

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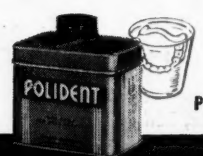

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